OF THE COUNTRY AROUND WITNEY 236

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GEOLOGY OF THE COUNTRY AROUND WITNEY

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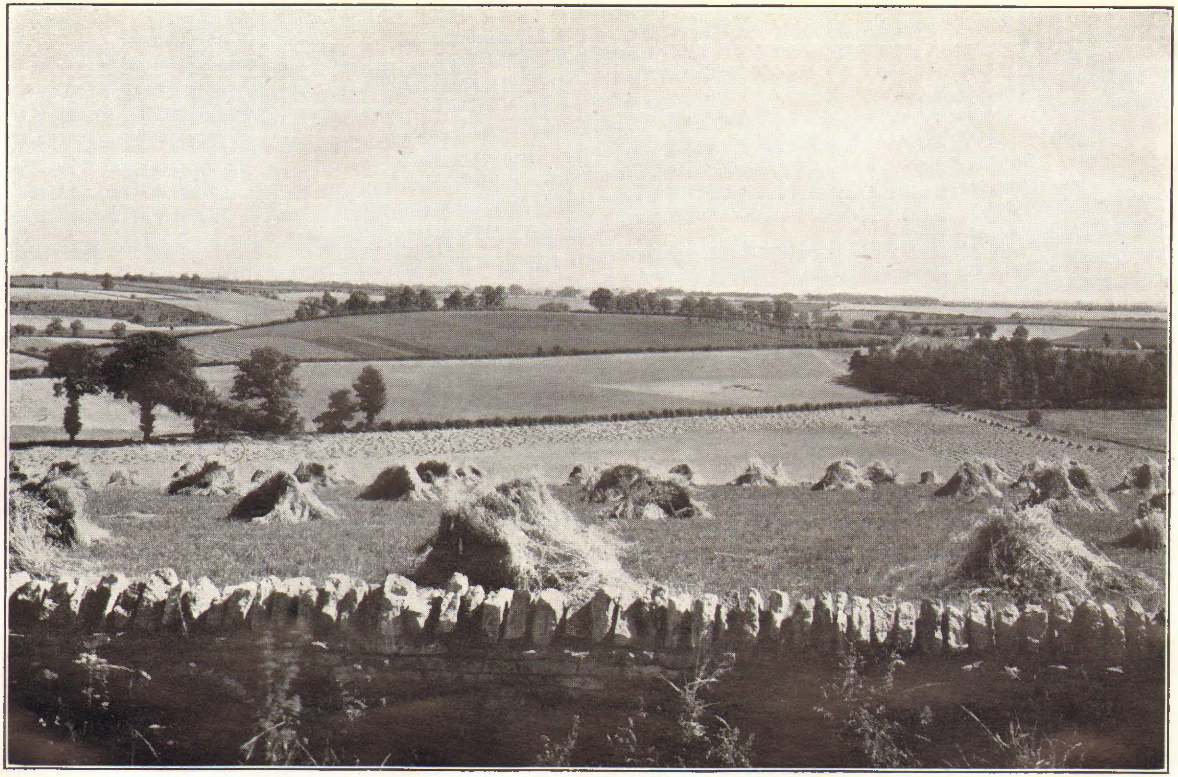

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ABANDONED MEANDER VALLEY OF THE RIVER WINDRUSH, AND MEANDER CORE, ASTHALL.

The rising ground in the centre of the picture is the meander core ; a small gravel pit is seen in the meander valley to the left of the wood on the right, while the present valley of the River Windrush is beyond the core.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

MEMOIRS OF THE GEOLOGICAL SURVEY
OF GREAT BRITAIN

ENGLAND AND WALES

EXPLANATION OF SHEET 236

Geology of the Country around Witney

By

Linsdall Richardson, F.R.S.E., W. J. Arkell, M.A., D.Sc.,
and
H. G. Dines, A.R.S.M.

With contributions by
C. G. T. Morison, M.A.

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PREFACE

The original geological survey of the solid rocks of the country covered by New Series One-inch Sheet 236, Witney, was carried out on the one-inch scale mainly by E. Hull, and published on Old Series Sheets 44 (1859, '97), 45 S.W. (1859, '71), 34 (1857, '59) and 13 (1859, '68). Each of the Old Series Sheets was accompanied by a descriptive memoir.

Much of the eastern half of the Witney district was re-surveyed (solid and drift) on the six-inch scale by the late J. H. Blake and Mr. T. I. Pocock between 1896 and 1901 and published on the one-inch Special Oxford Sheet in 1908, with a memoir by Mr. T. I. Pocock. A second edition of this memoir by Dr. J. Pringle, with an account of the drift deposits by Dr. K. S. Sandford, appeared in 1926.

The drift deposits of the remainder of the Witney district were surveyed on the six-inch scale, in 1935, '36, by Mr. H. G. Dines, who also, in collaboration with Mr. L. Richardson, made some additions and corrections to the mapping of the solid rocks.

The present memoir is a continuation of the earlier memoirs on the Jurassic rocks of the Moreton in Marsh and Cirencester districts, by Mr. L. Richardson. He has, in this case, been materially assisted by Dr. W. J. Arkell, who has written the chapters on the solid rocks above the Cornbrash, Mr. H. G. Dines has dealt with the drift deposits, and Prof. C. G. T. Morison, of the School of Rural Economy, Oxford, has contributed notes on soils and agriculture.

The memoir has been prepared for the press by Mr. Dines.

E. B. BAILEY,
Director.

GEOLOGICAL SURVEY OFFICE,
Exhibition Road,
South Kensington,
London, S.W.7.
17th November, 1942.

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GEOLOGY OF THE COUNTRY AROUND WITNEY

CHAPTER I

INTRODUCTION

By L. Richardson

AREA AND LOCATION

THE area described in this memoir is covered by the One-inch, New Series, geological map, Sheet 236. The larger part, to the north of the River Thames, is in Oxfordshire and the smaller part, to the south of the river, in Berkshire.

The University City of Oxford, situated on the eastern margin of the district, is becoming increasingly industrial, mainly owing to the proximity of the Morris Motor Works at Cowley. Witney is world-famous for its blankets; there is a glove factory in the town, and it is an important agricultural centre. Woodstock is also the centre of a large agricultural district. There are five glove factories here and two in Charlbury, and out-work for the firms is carried on as a cottage industry in many of the villages. There are blanket mills near Witney at Crawley Newmills and Asthall, an engineering works at Clanfield, breweries at Witney and Burford, and a large cement works at Shipton on Cherwell; otherwise the district is agricultural.

In 1903 Buckman (1903, pp. 205-250) gave the results of an attempt to define the Cotteswold Hills. In arriving at a decision as to the eastern limit, he concluded, " It does not seem possible to part the high ground of Wychwood and Leafield from the Cotteswold range. It is connected with the ridge of Barrington and Rissington by ground over 500 feet high; and as Burford, with the country round it, is considered Cotteswold, the best physical boundary on the north-east side is the Evenlode : that of necessity makes the area of Wychwood Forest an eastern extension of the Cotteswolds." " For the south-eastern boundary from Witney I have taken roughly the limit of the Cornbrash, where it dips under Oxford Clay . . . By this line we include in the Cotteswolds, Brize Norton, Broughton . . ." Some, however, prefer to regard the eastern limit of the Cotteswolds as following the bottom of the ' Maugersbury Gap,' between Stow on the Wold and Church Iccomb, to the River Windrush at Bourton on the

Water, the Windrush down the Vale of Bourton to the Oxfordshire county-boundary near Burford, and thence along that boundary southward to the outcrop of the Cornbrash (*see* Richardson 1935, p. 404). If this preference is adopted no part of the present district comes within the Cotteswold Hills. In the heyday of the Cotteswold wool trade Burford was not engaged in the wholesale trade, but in such subsidiary occupations as the fulling and cleaning of wool, weaving, etc.

Wychwood Forest originally extended from Taynton, near Burford, in the west to Kidlington in the north-east, and from Cleveley, near Enstone, in the north to Stanton Harcourt in the south-east. In the middle of the past century saddle-making was a flourishing industry at Burford, the saddles being made from the skins of swine that roamed wild in the Forest. In 1862 the Forest was broken up and sold, and only 1,500 acres adjacent to Cornbury Park remain.

Physical Features and Geological Formations

The Witney district is for the most part open country in which there is a close relationship between geologic structure and land-relief. The highest ground, a scarp feature, extends from Habber Gallows Hill, south of Milton under Wychwood, eastward through Langley to Stag's Plain, north of Wychwood Forest. The crest line is mostly above 600 ft. O.D., from which level the ground falls steeply northward to the Evenlode valley (300 ft. O.D.) and slopes gently south-eastward to the Thames valley (200 ft. O.D.). Broadly speaking the gentle south-easterly slope extends across nearly the whole of the district, forming the dip-slope of the strata, except in the south-east corner, near Oxford, where there is ground rising above 500 ft. at Boars Hill. For additional information on the subject of land relief the reader is referred to the work of Beckit (1926).

The solid formations outcropping within the district are of Jurassic age, with the exception of the small outlier of Cretaceous Lower Greensand and Gault capping Boars Hill. The outcrops of the alternating Jurassic limestones and clays stretch across the district roughly north-east by east, but their regularity has been disturbed to some extent by flexing and faulting both along the strike and transverse thereto. In the low ground in the north-west the Lower Jurassic or Liassic formations are exposed, the Lower Lias forming the floor of the Evenlode valley. The main scarp-feature consists of Middle Jurassic limestones, comprising Inferior Oolite, Fullers' Earth, Great Oolite, Forest Marble and Cornbrash. Together their outcrops occupy a belt of country some six miles wide extending across the north-west half of the district. The line separating them from the overlying Oxford Clay extends from Kencott near the south-west corner to the north-east corner, almost dividing the map diagonally into two equal parts. The south-eastern half of the district is occupied by Upper Jurassic strata. The outcrop of the lowest member of this division, that of the Oxford Clay, is by far the most extensive, being nowhere less than seven miles wide. It forms the floor of the Thames valley and supports nearly the whole of the river drift present in the area. In the high ground of the south-eastern corner, around Cumnor, Wootton and Sunningwell, and in the outlier of Wytham Hill, are found the remaining members of the Upper Jurassic of this neighbourhood, namely, the Corallian Beds and the Kimmeridge Clay, the latter with the remnant of Lower Greensand resting unconformably upon it.

Superficial deposits of Pleistocene and Recent age include both glacial and river drifts. They are patchy and nowhere seriously mask the boundaries of the underlying solid formations. The glacial deposits occur mainly scattered over the higher ground though some boulder clay and glacial gravel occupies the Evenlode valley in the north-west. River deposits are associated with all the streams but are only extensive in the Thames valley, the river being bordered by a wide belt of alluvium and gravel throughout its course across the Oxford Clay.

The following formations are distinguished on the colour-printed edition of Sheet 236 of the Geological Survey map:—

	Formation	Thickness Ft.	Age
Superficial	Alluvium: up to	15	Recent and Pleistocene
	Brickearth: up to	10	
	Valley Gravel: up to	30	
	Glacial Deposits: up to	20	
	Gault: up to	10	Cretaceous
	Lower Greensand	50	
	Kimmeridge Clay	92	Upper Jurassic
	Corallian Beds: up to	80	
	Oxford Clay and Kellaways Beds: about	400	
	Cornbrash	8-14	Middle Jurassic
	'Forest Marble' Wychwood Beds: 0-27 ft. Kemble Beds: 12-21 ft.	12-48	
	Great Oolite Series (including the Stonesfield Slate Beds at the base): up to about	120	
	Fullers' Earth Series: up to about	50	
	Inferior Oolite Series	0-35	

BORINGS IN THE WITNEY DISTRICT[1]

Formations	Burford Signet		Witney		Ramsden		Wytham		Oxford City Brewery		Oxford St. Clement's Brewery		Kidlington	
Approx. Ht. above O.D. in ft.	345		278		478		206		209		203		213	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
Alluvium							15	0					11	0
Gravel					6	0			30	0				
Oxford Clay and Kellaways Beds ...					21	0	258	0	210	0	265	0	2	0
Cornbrash			43	0	11	0	17	0	17	0	155	0[2]	13	0
Forest Marble					25	0	26	6	32	8			20	6
Great Oolite Series	62	6	141	6	142	0	96	0	116	6			180	6
Inferior Oolite	27	8	30	0	27	0	35	6	16	4			7	0
Upper Lias	81	6	55	6+	128	0+	14	6	—				233	0+
Middle Lias	98	1					170	6+	—					
Lower Lias	447	4							17	0+				
Rhætic and New Red Marl ...	466	11												
Coal Measures	226	0												
	1410	0	270	0	360	0	633	0	439	6	420	0	467	0

---

[1] The details of the Burford boring were given by Woodward (1894, pp. 303, 304), those of Witney, Wytham, and St. Clement's also by Woodward (1894, pp. 372, 513; 1895, pp. 42, 43) and of the City Brewery boring, Oxford, by Pringle (1926, pp. 174-176).

[2] The thickness of rock-beds has been given as 135 ft., but Prestwich (1876, pp. 238, 239) recorded 155 ft. at the St. Clement's Brewery.

Formation	Thickness Ft.	Age
Upper Lias	0-81	Lower Jurassic
Middle Lias Marlstone: 10ft. Sandy Beds: 15ft. ...	0-25	
Lower Lias	447	

In connexion with the above list it is important that attention should be drawn to these points :—(a) the thicknesses given for the Lower and Upper Lias are taken from the record of the Burford Signet boring (*see* table opposite), while those of the Sandy Beds and the Marlstone of the Middle Lias are the maxima for these subdivisions as noted at their outcrops, the thickness of strata assigned to the Middle Lias in the boring being 98 ft. (b) The Fullers' Earth Series, at the outcrop, is mainly Chipping Norton Limestone. The green colour on the map represents the outcrop of this limestone as well as the locally developed Sharp's Hill Beds, the Upper Estuarine Clay and, possibly, traces of a representative of a part of the Fullers' Earth Clay. (c) Both in the list and on the geological map the Stonesfield Slate Beds are included in the Great Oolite Series, but, as stated in Chap. IV, it has been convenient to describe these beds with those of the Fullers' Earth Series.

There is no fresh information concerning the concealed strata of the district to add to that already given by Pringle (1926, pp. 2-5), but for convenience the table published by him is reproduced here with the addition of surface levels. The sites of the boreholes recorded in the table and some others of less importance are shown in the geological map.

Drainage

River Thames.—The whole of the district is in the drainage-basin of the Thames or Isis. The river enters about the middle of the southern margin, flowing a little north of eastward, but near Appleton turns northward and then makes a great curve round by way of Eynsham, Wolvercot and Oxford, leaving the district at the south-eastern corner (*see* Fig. 4, p. 106). Until reaching Wolvercot, at the northern point of the curve, the river is a strike stream meandering along the Oxford Clay outcrop, but, at that point, in turning south-south-east it becomes a dip stream and passes from Oxford Clay on to the overlying Corallian Beds, three miles south of Oxford, where its valley narrows considerably. Throughout the whole of the course over the clay country the valley is wide, with very gently sloping sides. The outstanding feature, which is brought out strikingly in the geological map, is the fact that the river, during its later stages, has been steadily moving, with the dip of the strata, towards the south. This is evident from the way in which it hugs the right hand margin of its alluvial tract, but is brought out more convincingly by the extensive spreads of gravel deposited only on the left bank, the right bank being somewhat steeper and almost free from gravel. Though the gravels are clearly laid down on terrace features, the continual southward migration of the stream has resulted in unbroken deposition on the left bank giving rise to a mantle of gravel in which it is not possible, in many cases, to delineate satisfactorily the boundaries between the terraces.

No tributary of importance enters the Thames on its right bank, but on its left it is joined by the Windrush, Evenlode and Cherwell and some minor streams. The major tributaries, within the present district, are dip streams, crossing limestone country, and in consequence are confined to narrow gorge-like valleys which contrast strongly with that of the Thames, and terrace gravels are rare.

River Windrush.—The Windrush rises close to the western edge of the Cotteswold Hills and enters the present district west of Burford. Thence it flows past Witney to the Thames at Newbridge. Between Burford and Witney the river is a ' misfit ' in its valley. Its tendency has been to move southwards with the dip of the rocks and in so doing it has produced many pronounced meander cliffs. The last chapter in its history, however, deals with the filling-in of its valley and the creation of a flood plain in which for the most part it now meanders on a scale that markedly emphasises its misfit. Remnants of terraces are to be seen near Minster Lovell and in an abandoned meander valley at Asthall (illustrated in the frontispiece), and small spreads of flood-plain gravel occur in one or two places. In addition to the Asthall abandoned meander, appearances suggest that there is another at Witney where a considerable part of the town seems to stand on a low meander-core of Cornbrash.

Owing to the prevalent southerly dip of the strata between Burford and Witney the river receives a considerable quantity of water from tributaries on the north side but practically none from the south. The river has been impounded for a number of mills: for example, for Widford corn-mill (disused), 200 yds. above which the water once broke through the levee and disappeared through a swallow-hole, now stopped up. At about half a mile east of Asthall church there are two ' tub holes,' from which water, coming presumably from the Windrush, emerges and rushes into a ditch called ' Doctor's Ditch.'

No doubt water finds its way down the valley through the superficial deposits, but locally the alluvium is very clayey and practically impermeable and rests on ' solid ' rock. It is noteworthy that the well (49 ft. 4 in.) of the Witney Urban District Council's waterworks in the valley at Apley, though sunk below river level, yields inadequately at times.

River Evenlode.—The Evenlode has its sources in the Vale of

Moreton; that part of its valley in the north-west corner of the present district, where Lower Lias is exposed, may be regarded as the southern extremity of the Vale. Its volume is being gradually diminished by the headward growth of the tributaries of the River Stour which belongs to the Severn system; no doubt the ' misfit ' of the present river, well seen between Charlbury and Hanborough, is in part due to this cause.

Between North Leigh and Ashford Mill the course of a small brook and associated land-relief features suggest an old meander course. Davies (1923, pp. 90, 91) assigned it to the Evenlode, but Bromehead (1909, p. 141) regards it as part of an old course of the Windrush. Davies has also suggested that the crescentic sweep of the steep valley side north of Long Hanborough is connected with an abandoned meander of the Evenlode.

Where the river cuts through the escarpment of the Great Oolite White Limestone, its valley is narrow and gorge-like. In the part of the railway cutting east of Combe Bridge, to the south of the village of Combe, is displayed, in the words of Hull (1859, p. 28), " an interesting section, where we see the beds of the Great Oolite worn into a channel which has afterwards been filled in by gravel [Hull's Lower-Level or Valley Gravel] of this period."

The Evenlode is joined by a south-flowing tributary, known as the River Glyme, at Bladon. Though small, this stream has carved a large incised meander in the Great Oolite south of Blenheim Park. Above the meander the stream has been dammed to produce the lakes in the Park.

River Cherwell.—This river enters the district north of Enslow Bridge and, flowing southward through Hampton Gay, Kidlington and Water Eaton, follows a course parallel to the Thames which it joins below Oxford. Part of a conspicuous old meander, the ' Tackley Meander,' of the Cherwell occurs to the north of Enslow Bridge: Pound Hill is its core. The meander is as described by Davies (1923, pp. 92-94) except that the gravel in it is not in the floor of the meander valley, but well up on the south-western side of the core. The meander is rather narrow and elongated along a line nearly at right angles to the present stream course, and the slopes of the core are steeper towards the river than away from it. In common with the Thames, this river has wide alluvial tracts where it crosses the Oxford Clay.

Minor Tributaries.—The more important of these occur in the area west of the Windrush and include Broadwell Brook, Shill Brook and Highmoor Brook with the Norton Ditch. Between the Windrush and the Evenlode there are the Limb Brook and the Chill Brook, both very small streams that act as drainage channels for the Oxford Clay area and are often dry. The larger of these tributaries are all dip streams fed by overflow springs from the limestones to the north of the Oxford Clay outcrop; the valleys cut in the limestones are narrow and often dry, the streams emerging at surface only after lengthy periods of rain. Across the

Oxford Clay, however, the valleys widen out and the streams are more persistent. The valley of the Highmoor Brook begins near Stonelands Farm close to the Witney-Burford road, but the bulk of the drainage of the basin above Brize Norton emerges as the Seven Springs close to the village. At Ven Bridge, on the 27th August, 1934, this brook and the Norton Ditch were dry. The Highmoor Brook flows through Bampton, where it is known as the Mill Brook, thence to Isle of Wight Bridge where it joins the Great Brook, which discharges into the Thames at Shifford.

The nature of these streams is well illustrated by the Shill Brook which rises in springs thrown out by marly layers in the White Limestone of the Great Oolite in Rangehill Copse about three-quarters of a mile to the south of Windrush (Sheet 235). A well defined valley with watercourse runs from this source and enters the present district near Signet, at which hamlet it is joined by a tributary coming from the north-west. In spite of small springs (also thrown out by marly beds in the White Limestone) at Westwell (Sheet 235), the watercourse is streamless, except for a month or two in the year, as far down as Signet. At times when the brook is flowing, the usually dry valley immediately west of the Burford-Lechlade road becomes flooded (*see* Richardson 1935, Pl. 32A). The Signet tributary, owing to the persistence of a spring thrown out from the base of the White Limestone by the Hampen Marly Beds (table p. 72), continues to flow when the upper part of the Shill Brook is dry. In wet weather, springs issue by the east side of the road in the hamlet and the water that emerges is no doubt responsible for a circular subsidence that is in progress in the allotments to the northward. The brook has been observed to lose water in swallow holes in three places near Sturt Farm, but now one is choked with mud and another has been filled in. On 1st September, 1933, water was running as far as the southern end of Sturt Copse whence it was dry to a little below Well Head above Shilton, where there is usually a good spring but on that date it was dry. Water appeared, however, a little lower down, and a good stream was flowing through the village. Well Head is obviously an overflow spring, and the positions at which springs issue in this part of the valley depend on the height of the water-table.

About 1½ miles below Shilton is an old meander, the core of which is indicated on the map south of Kenn's Farm by the little oval of elevated ground contained by the 300-ft. contour.

According to Dines what looks like an impending capture of the Shill Brook by a tributary of the Highmoor Brook has been artificially assisted. The Shill Brook proper flows about south-east on the west side of Black Bourton, and another small stream, apparently rising from the gravel, starts in the village and flows eastward to Bampton. A mill leat appears to have been constructed, taking water from the Shill Brook near Moat House to join the small easterly flowing stream and feed the pond of the cornmill near Lower Farm. The Shill Brook below Black Bourton is therefore deprived of some of its headwaters. It joins the Sharney Brook south of Weald and so reaches the Thames.

VALLEY FORMATION IN JURASSIC LIMESTONE COUNTRY

The Witney district affords a considerable amount of information as regards the formation of valleys in a Jurassic tract in which comparatively thick limestones with clay partings occur. It also throws light on the origin of dry valleys such as are so characteristic a feature of the Cotteswold Hills.

The slope of the country is southward and as this is less than the dip of the rocks, apart from the Leafield outlier of Oxford Clay, newer and newer rocks come on towards the south. As seen from certain view-points the slope of the country in the neighbourhood of the line of section, Fig. 1, appears to be steeper to the north of the Windrush than it does to the south, but this impression is in the main illusory and due to the number of valleys that run into the Windrush valley on the left bank and their absence from the south bank.

The reason for the frequent occurrence of valleys on the left bank is due to the fact that on this side the dip of the rocks is towards the river, while on the right bank it is away from it.

Unbedded drift caps the Oxford Clay of the Leafield and Ramsden Heath outliers. The springs from the base of the drift, thrown out by the underlying Oxford Clay, are actively engaged in the destruction of the drift and Oxford Clay caps: in The Gorse Field, Ramsden Heath, the water has made a way through the feather-edge of the Oxford Clay into the underlying Cornbrash creating swallow-holes, and surface-drainage of Oxford Clay has done the same thing at Combe.

Water from these highest springs, after running over the outcrop of the clays of the Wychwood Beds of the Forest Marble, and from weak springs such as Easewell near Brize's Lodge from limestones associated with the clays of the Wychwood Beds, sinks into the White Limestone of the Great Oolite. Small springs are thrown out locally (as at Whiteoak Green) by thin clay beds in the White Limestone, but the bulk of the normal discharge of the highest springs finds its way downwards through the fractures in the White Limestone to the next water-upholding clay—the Hampen Marly Beds of the Great Oolite.

Springs thrown out by the Hampen Marly Beds break in the valley at and above Fordwells and north-west of South Lawn in the Swinbrook valley. It is obvious that these are working headwards: below Potter's Hill, near Leafield, the head-sides of the valley in the White Limestone rise almost precipitously above the uppermost spring from this horizon.

Where conditions are suitable, water thrown out by the Hampen Marly Beds finds its way into the subjacent division of the Great Oolite, the Taynton Stone, to be thrown out again by the underlying clays between the Taynton Stone and Chipping Norton Limestone of the Fullers' Earth Series. Numerous springs are thrown out by these clays in the Swinbrook valley.

Upper Lias clay does not appear in the neighbourhood of the part of the Windrush valley traversed by the line of section, Fig. 1, but is responsible for abundant springs at the base of the Clypeus Grit (Inferior Oolite) in the Evenlode valley and the strong spring that supplies Burford.

All these springs are engaged in cutting headwards, and it is clear that the tributary valleys of the Windrush on the left bank between Burford and Witney are all in the process of being excavated and deepened headwards by perched gravity springs at several levels.

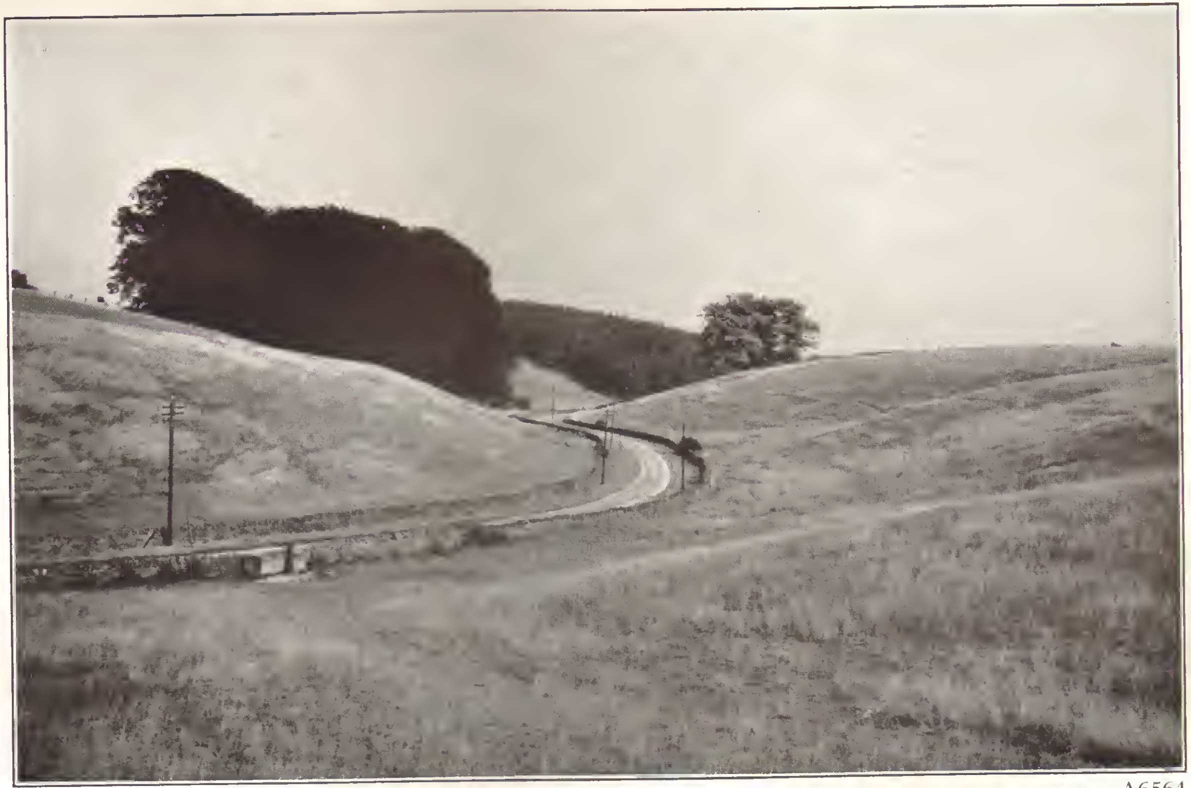
The Newell Brook, which drains Wychwood Forest and Cornbury Park, is fed by visible springs such as Newell and Cyde Well, issuing from the base of the Clypeus Grit, but the bulk of the water discharged by these springs and certain others will have been derived from springs, the water from which has been thrown out by higher clay beds, and has percolated down through the rocks.

After lengthy periods of rain much water courses down the Fordwells, Swinbrook, Whiteoak, and lesser valleys above ground, but on the lessening of the supply, the brooks locally subside into the ground. When the water is moving below the surface, the gravitation of the rainfall on the valley sides is to the main line of drainage, and when the brook is subsiding, lowering of the valley floor must take place by solution of the limestone at and near the surface.

In the tract north of the Windrush, when the clay cap above the Great Oolite has been removed, dry valleys will result above the springs thrown out by the Hampen Marly Beds, and when the escarpment to the north has been sufficiently denuded southwards the dry valleys will become wind-gaps and later through valleys. The north-western head-valley of the Swinbrook commences in the neighbourhood of the cross-roads east of Shipton Barrow very close to the escarpment that overlooks the Evenlode valley.

Attention may be directed here to the impressive Dean Bottom dry valley to the north of Fulbrook : a curious occurrence here is the appearance of a strong spring from the base of the Clypeus Grit (from which it is thrown out by the Upper Lias clay) not in the valley bottom, but at the foot of a promontory between this valley and that in which Waterloo Farm is situated. There are several cases of similar phenomena in the district.

Considering now the country south of the Windrush, we shall see that if a river valley were excavated below A (Fig. 1) tributary valleys would be formed on its left bank in a similar manner to those on the left bank of the Windrush.



A6564

FORDWELLS ' DRY ' VALLEY, LEAFIELD.
View southward from below Potter's Hill.

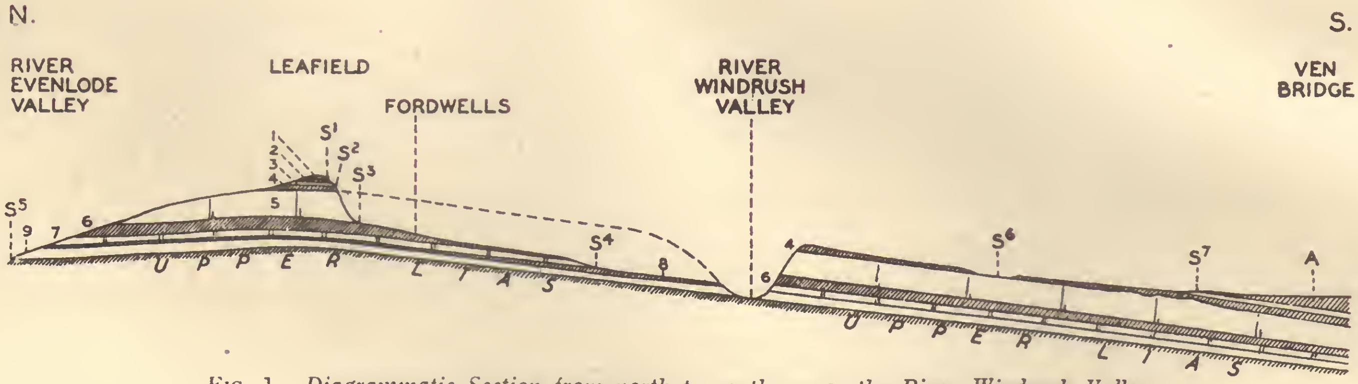


FIG. 1.—*Diagrammatic Section from north to south across the River Windrush Valley.*

Spring :—	from the base of the :—	thrown out by the :—
S1	Unbedded Drift (1)	Oxford Clay (2)
S2	Cornbrash (3)	Wychwood Beds (4)
S3	White Limestone (5)	Hampen Marly Beds (6)
S4	Taynton Stone (7)	Estuarine Clay, etc. (8)
S5	Clypeus Grit (9)	Upper Lias

S6 is an inflowing spring and S7 an overflow spring. A, see text.

To the south of the Windrush, however, valleys are being produced mainly by the migration down stream of overflow or artesian springs. Between Brize Norton and Grove Farm springs (S6, Fig. 1) may be observed coming off the clays of the Wychwood Beds of the Forest Marble and disappearing into the underlying limestone to emerge, in combination with water from other sources, as overflow springs (S7) at the margin of the Oxford Clay. In the neighbourhood of Brize Norton the Wychwood Beds clays are locally very thin and it appears probable that overflow springs emerging in Cornbrash ground are largely of water from underlying limestones that has broken through the thin covering under artesian pressure. As time goes on the head springs will grow headwards and the overflow springs recede down stream.

Between Signet and Shilton the Shill Brook in part flows over White Limestone. When the water-table falls water has been observed to disappear from the brook into small swallow-holes south-east of Sturt Farm and the valley between here and Well Head to go dry. On the other hand, when the water-table rises Well Head flows copiously, and it is probable that, as in the bed of the Churn, north of Cirencester (Richardson 1930, p. 42), water emerges from the swallow-holes. As mentioned on p. 8 one swallow-hole is choked with mud and another has been filled in to prevent loss of water from the stream, but there may be others, for once when the stream was accidentally dammed the water rose, overflowed, and ran away into the ground.

It would appear, then, that the breaking through into the underlying limestone of perched gravity springs from a clay cap, the originating of overflow or artesian springs, and their working apart, one up and the other down stream, are the origin of many valleys in a district such as the present one. Moreover, with the lengthening of the valley and consequently increased catchment, the overflow springs would be expected to increase in volume and fretting power. The springs at Broadwell and the Seven Springs at Brize Norton are overflow springs.

In the case of the valleys where the water-table periodically rises above surface and subsides underground, the writer is of opinion that considerable lowering of the valley-floor is effected by decalcification of the limestone within the limits of fluctuation of the water.

In the bottoms of the valleys there are locally deposits that may be largely residual, but when the bournes are flowing, a considerable quantity of matter will be carried down stream to be added to the alluvial deposits of the lower reaches of the stream or to those of the main river. The dry valleys of the Cotteswolds and of this district are seldom viewed by the casual observer when the bournes are running and parts of the valleys are flooded (Richardson 1933, Pl. I; 1935, Pl. 32A).

The writer doubts if solution of underground limestones in this and adjacent districts causing, by collapse, sagging of the surface, has been accountable for dry valleys to the extent that has sometimes been considered likely. He once descended a deep well in the bottom of one of the most marked dry valleys in the Cotteswolds (Richardson 1915, pp. 27, 28), but saw no sign of any removal of the basal strata by solution. It is admitted, however, that solution or decalcification of the rocks by underground water running over clay beds has caused settlement and sagging of the surface where the Chipping Norton Limestone is involved, owing to the proneness of this subdivision to undergo decalcification.

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CHAPTER II

LIAS

By L. Richardson

Lower Lias

THE Lower Lias, the oldest formation outcropping in the district, occurs in the neighbourhood of Milton, Shipton, and Ascot under Wychwood. Only the upper part emerges at the surface and no sections worthy of note are now available, but there are indications of a clay formation, apparently similar to what is met with in equivalent position in the neighbourhood of Cheltenham.

A list of the zones of the Lower Lias is given in ' The Country around Moreton in Marsh ' (Richardson 1929, Table A). A number of records of the occurrence of ' *Ammonites capricornus* ' suggests that the Capricornus Beds, at the top of the formation, which are very persistent as regards lithology and fauna in Gloucestershire, Warwickshire, etc., maintain similar characters in this district.

The thickness of the Lower Lias beneath Burford Signet is 447 ft. 4in.: speaking generally the formation thins to the eastward, but to what extent precisely is not known.

Details

During the construction of the Oxford and Worcester Railway, cuttings were made in the Lower Lias at (1) Shipton under Wychwood Station, (2) north-east of Ascot, and (3) near Charlbury, but the sections have been long overgrown and there is no definite information as to the zones encountered. At Ascot " the skeleton of an Ichthyosaurus was found," (Hull, 1859, p. 9) and in the cutting near Charlbury, " Ammonites planicosta and Pleurotomaria," (Horton, 1860, p. 251) which are suggestive of Raricostatus Zone.

In the old pit on the west of the road just north of the bridge over the River Evenlode at Ascot, Hull (1859), p. 9) noticed the highest beds of the Lower Lias consisting of bluish shales, weathering grey and brown, with small nodules of earthy limestone and iron concretions. The beds are now poorly exposed and no fossils have been obtained.

In an overgrown pit at Fawler, once worked by Messrs. Bolton and Partners, there is a 20-ft. bed of clay between 11 and 31 ft. below the Marlstone of the Middle Lias. Bather (1886, pp. 143-145) found " in its upper part *Ammonites margaritatus* and slightly below, *A. capricornus,*" and a boring proved similar blue clay up to a depth of 100 ft. Bather remarked that a sharp anticline brings up the Lower Lias here.

In the Burford Signet boring " *Ammonites capricornus, Cardium truncatum, Avicula, Pecten,* etc.," were found at 10 ft. 3 in. below where the base of the Middle Lias was placed (Woodward, 1894, p. 303). A boring at The Hayes, Ramsden, was stopped in the Capricornus Beds at 123 ft. below the base of the Inferior Oolite (Pringle 1926, p. 17), while another at the City Brewery, Oxford, yielded evidence for Capricornus Beds in the form of *Androgynoceras maculatum* (Young and Bird) at 8 ft. below the base of the Upper Lias, with no Middle Lias present (Pringle, 1926, p. 176).

MIDDLE LIAS

The Middle Lias consists of two subdivisions:—

The Sandy Beds: yellow, grey and brown sandy shales with occasional ferruginous nodules constitute the lower division. At the outcrop they are up to 15 ft. thick, but in the mid-northern part of the district, they are thinner and much more sandy than in the Cotteswold country to the west; they constitute sources of water-supply at Waterman's Lodge Farm (Cornbury Park Estate), Fawler and Stonesfield. Samples when freshly drawn from boreholes often merit the description 'clayey greensand.'

The Marlstone or Rock Bed: in the west this is, as a rule, an impure, blue-hearted limestone weathering brown, but eastwards it passes into a brown, green-hearted, finely oolitic limestone and is considerably ferruginous in the neighbourhood of Fawler (Blenheim Iron Ore). It is up to 10 ft. thick and rests on the Sandy Beds.

Beneath Burford Signet a thickness of 98 ft. 1 in has been assigned to the Middle Lias, but the formation is absent beneath Oxford.

DETAILS

There are no satisfactory sections in the district at the present time, and we are largely dependent on the observations of Hull (1857, p. 21). He remarked of a section to the north of Burford where the road to Fulbrook leaves the Stow road: " The Marlstone [a term he used for the Middle Lias] is exposed, with the blue shales . . . . which may be possibly those of the Lower Lias, in which case the Marlstone would only be about 6 feet in thickness . ." The exposure is now overgrown.

Referring to the fault west of Fulbrook, Hull said (1857, p. 22) that it brings " the Marlstone against the Great Oolite, which may be clearly ascertained by observation along the lane leading from Weston [now Westhall Hill] to Fulbrook, the Marlstone being there exposed to view." Typical Marlstone is still to be seen in a drainage channel alongside this road at about quarter of a mile west-south-west of Fulbrook Church.

A section from the Lower Lias to the Great Oolite in the bank alongside the road from Milton under Wychwood to Milton Quarries is now almost entirely overgrown. Hull (1857, pp. 21, 22) recorded:—Lower Lias, Marlstone (Rock Bed—brown sandstone overlying sandy shales), 24 ft.; Upper Lias (blue shale), 20 ft.; and Inferior Oolite [Clypeus Grit], 20 ft.

From a temporary exposure a mile east of Shipton, Hull (1857, p. 21) gives the following thicknesses:—Marlstone (*i.e.*, Rock Bed and Sandy Beds), 10 ft.; Upper Lias, 6 ft.; Inferior Oolite, 10 ft.

In the valley between South Lawn and Pain's Farm to the north of Swinbrook (' Knot Nook,' now Nutoaks), Hull (1857, p. 25) found Marlstone forming the bottom and separated " with scarce a trace of Upper Lias Shale " from the Inferior Oolite " lining the sides of the dell."

The Middle Lias extends down the Evenlode valley from Charlbury to Ashford Bridge, where Great Oolite is faulted against it, and reappears in an inlier at Stonesfield Ford to the south of Stonesfield. The outcrop of the Marlstone may be traced almost continuously, and, according to Hull (1859, p. 10), it is nearly 10 ft. thick in the railway-cuttings. The chalybeate water of the Roman Well (' Spa Well ' on the 6-inch map, Sheet 25 N.E.) by the side of the ornamental sheet of water known as Lake Superior in Cornbury Park, appears to come off Upper Lias clay.

Hull discovered the Marlstone at Fawler and drew attention to its ferruginous nature. Its exploitation was almost immediately undertaken and under the name of ' Blenheim Iron Ore ' it was worked, with a brief interval, from 1859 to 1887 (*see* p. 138). At the present time the ironstone is seen *in situ* only in small outcrops around Fawler. Some loose blocks contain ' nests ' of *Lobothyris punctata* (J. Sowerby).

At three quarters of a mile north-by-east of Wilcote church is Hull's section " in the lane leading from Fawler to Topples [now Tapples] Wood." He noted (1859, pp. 9, 10):—

" 1.	Great Oolite	...	White shelly oolite (not well seen).
2.	Inferior Oolite	...	Coarse rubbly oolite, 6 feet thick.
3.	Upper Lias	...	Grey shales and clays, 5 feet.
4.	Marlstone rock-bed	...	Iron Ore, 8 feet.
5.	Marlstone sands	...	Fine sands, with balls of concretionary iron ore in the topmost bed, 15 feet."

Brown ferruginous Marlstone is still fairly well exposed. Fragments of Clypeus Grit (2) are seen lying about, and higher up, pieces of hard, grey, oolitic Chipping Norton Limestone, which formation Hull included in the Great Oolite.

A small outcrop of Marlstone is seen at the ford south of Stonesfield and there are blocks of the rock on the wall of the neighbouring enclosure.

Upper Lias

The Upper Lias consists of blue clay with, at the base, as a rule, a thin layer of earthy limestone crowded with ammonites.

The thickness of the Upper Lias varies considerably; in the Evenlode valley it decreases from 20 ft. in the west to between 5 and 16 ft. at Fawler; it thickens to the north-east being probably over 48 ft. thick at Kirtlington (a mile north of Bletchingdon; the name does not appear on the one-inch map); beneath Burford Signet it is said to be 81 ft. 6 in. thick, while it is absent beneath Oxford.

Details

According to Hull (1857, pp. 22, 25; 1859, p. 10) the thickness of the Upper Lias (1) at the junction of the Stow and Fulbrook roads north of Burford is 6 ft. (blue shales); (2) at Nutoaks, a mile north of Swinbrook, a mere trace; (3) in the hill south of Milton under Wychwood, 20 ft., blue shale (Hull noted ' *Ammonites annulatus,*' but put them in the Marlstone; (4) about a mile east of Shipton under Wychwood, 6 ft.; (5) in the lane section north of Topples Wood, between Fawler and Wilcote, 5 ft. (grey shales and clay); and (6) according to Green (1864, p. 10), at Charlbury, 10 ft.

From an excavation at the Post Office Pumping House alongside the Coldwell Brook, and south of the Charlbury road south of Ascot under Wychwood, Pringle collected the following Upper Lias fossils :—*Dactylioceras* cf. *gracile* (Simpson) (hemera *exarati*), *Hildaites levisoni* (Simpson) (*Hildaites*), *Harpoceras mulgravium* (Young and Bird) (*falciferi*), *Harpoceras sp.*, and a *Gryphaea*.

At Fawler the Upper Lias was once well exposed in the ironstone workings and several authors have contributed information differing somewhat in details (Woodward, 1893, p. 268; Bayzand, 1909, p. 28; Richardson, 1910, p. 31; Sollas, 1926, pp. 34, 35). According to Arkell (1933, p. 175): " Nearly all the Whitbian zone-fossils are present at the base of the clay, in a thin layer of earthy limestone crowded with ammonites."

A boring made for Manor Farm at Fawler in 1931 proved Upper Lias clay 14 ft. thick.

Upper Lias clay at least 5 ft. thick is seen between the Marlstone and steeply inclined Clypeus Grit at the ford south of Stonesfield, and the boring at the old rectory, Stonesfield proved a thickness of 9 ft. 6 in.

In 1934 a boring made at Waterman's Lodge Farm at 545 ft. O.D. near the tumulus on Cornbury Park Estate, was carried to a depth of 248 ft. It proved Upper Lias between 168 and 199 ft. down.

When excavations in connection with the new bridge over the River Windrush were made in 1933, an inlier of Upper Lias clay was disclosed beneath some 6 ft. of Alluvium.

Upper Lias was entered at a depth of 196 ft. down in the Furzey Hall Boring, Filkins (Sheet 235), (p. 40), and was passed through by the borings at the Police Station, Witney (thickness not determinable), and near The South Lodge, Wytham (thickness, 14 ft. 6 in.).

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CHAPTER III

INFERIOR OOLITE

By L. Richardson

IN the Cotteswold Hills to the west of the present district the Inferior Oolite is separable into numerous subdivisions of which the highest is the Clypeus Grit. On Leckhampton Hill, Cheltenham, the Clypeus Grit is separated from the Upper Lias by some twelve subdivisions totalling close upon 200 ft. in thickness (*see* Richardson 1929, p. 36; 1933, p. 14). The Clypeus Grit extends into the present district maintaining its faunal and lithic characters, but is separated from the Upper Lias by only a thin Basement Bed. There is thus a great non-sequence between the Inferior Oolite and underlying Upper Lias. There may be a trace of Inferior Oolite beneath Oxford (Pringle 1926, p. 176), but the information obtained from a boring at Kirtlington confirms the opinion that it is absent from the north-eastern part of the district and that in that part the Hook Norton Beds (*see* table on p. 23) rest directly on the Upper Lias clay.

Basement Bed

This bed has been observed at Cyder Well, east of Churchill Copse, in Wychwood Forest, at a spring discharging into the southern side of Lake Superior in Cornbury Park, and at Fawler.

At Cyder Well some large slabs of the bed may be seen lying about; it is a hard brown limestone, with softer fawn-coloured parts, and sparsely-distributed iron grains. Occasionally the bed includes small, smooth pebbles of Upper Lias limestone and specimens of *Ataphrus laevigatus* (J. Sowerby). The rock seen at the spring is similar, but contains in addition specimens of *Pleuromya*. The date of the bed is either late *garantianae* or early *truellei* hemera.

From the Basement Bed at Fawler, Walford (1885, pp. 38, 39) recorded "... corals ... blocks of limestone covered with oysters and pierced with *Lithodomi*, numerous shells such as *Astarte minima, Ostrea marshii, Isocardia*, sp., *Trigonia producta, T. costata*, and *T. angulata*." The author's experience has been very similar (1910, p. 31, 1911, p. 202) (*see* record, p. 20), and he would date the bed as *truellei*. It may contain fossils derived from a thin deposit of hemera *garantianae*, and there is no reason why it should not yield fossils derived from rock of hemera *scissi*. *Rhynchonella subdecorata* Davidson, a brachiopod characteristic of the Scissum Beds, has been found in the basement-bed (Pringle 1926, p. 11). Caution, however, has to be exercised in this matter for in the Cotteswolds the present author has noticed that occasional specimens of a variety of *R. subdecorata* in the Scissum Beds are similar in appearance to a variety of *R. subtetrahedra* that occurs not uncommonly in the Upper Coral Bed. C. J. Bayzand (*in* Sollas 1926, p. 34, Fig. 1) appears to have seen a separate bed with corals above the Basement Bed; where such is the case the Basement Bed may still be dated *truellei* and the Coral Bed a little later in the same hemera. (*See also* Arkell 1933, p. 244).

CLYPEUS GRIT

The Clypeus Grit crops out in the sides of the valleys of the Evenlode and its tributaries as far south-eastward as Ashford Bridge and there is an inlier at the ford south of Stonesfield. It flanks the valley of the Windrush around Burford and forms inliers at Swinbrook; and, according to Hull (1857, p. 25), at ' Knot Nook ' (now Nutoaks) to the north of Swinbrook.

In the hills to the south of Milton under Wychwood the Clypeus Grit is 20 ft. thick (1857, p. 22) and at Fawler, 17 ft. In a shaft at Stonesfield, which was deepened, on the instruction of the Duke of Marlborough, to ascertain the depth at which the Marlstone iron-ore occurred there, Hull (1860, p. 304) recorded a thickness of 30 ft. for what is obviously Clypeus Grit.

In this district, as a rule, the lower half of the Clypeus Grit consists of massive limestones and the upper half of rubbly limestones packed with fossils—notably *Terebratula globata* Auctt. and *Clypeus ploti* Klein. The topmost part eastward, as at Fawler, is more marly than usual: it is on the horizon of an ironshot oolite found in places in the North and Mid Cotteswolds (Richardson 1929, p. 44).

DETAILS

Typical Clypeus Grit is exposed on the north side of the road to Fulbrook some 350 yds. north of Burford Church; at the spring three-fifths of a mile north of Fulbrook Church; by the road 200 yds. north of the bridge at Swinbrook; in the dell at Nutoaks, a mile north of Swinbrook, and at Buckleap, half a mile south-east of Cornbury House. According to Hull (1859, p. 13), at the last locality " The stratum is very thin. and consists of large-grained rubbly oolite ", but probably it is of much the same thickness as at Fawler, for, in Newhill Quarry near Churchill Copse, is displayed Clypeus Grit similar to its development at Fawler and of about the same thickness. The Roundhill Clay and disturbed flaggy Chipping Norton Limestone are exposed above, and Upper Lias clay below. The rocks in this quarry have slipped; but it is noteworthy that springs such as Cyder Well, in ' The Forest,' indicate that the base of the Clypeus Grit here occurs at about 400 ft. O.D., while those at

Rushey Bank near Charlbury Station, and to the north of Park Farm, show that the lower limit is there about 300 ft. O.D.

In the lane section north of Topples Wood, south of Fawler, p. 16), Hull noticed a thickness of 6 ft. for the Clypeus Grit. Traces of Clypeus Grit, with tough black Roundhill Clay above, have been seen in the bank alongside the road at Ashford Cottages south of Ashford Mill, and the subdivision is well exposed in an inlier at the ford south of Stonesfield.

After Newhill Quarry, the best sections of the Clypeus Grit in the district are those in the old ironstone workings at Fawler.

Succession at Fawler

		Ft.	Ins.
Chipping Norton Limestone			
Fuscae?-zigzag	Limestone, white, oolitic; few fossils: seen up to	15	0
Clypeus Grit			
schloenbachi (probably)	Marly beds consisting, in descending order of *Nerinea* Bed, '*Terebratula globata*' Marl, impure limestone, *Pholadomya* Marl, and marl with indurated parts	4	0
schloenbachi	Rubbly Beds: Limestones, rubbly, coarsely oolitic; *Clypeus ploti* Klein, etc.	4	0
schloenbachi and *truellei*	Massive Beds: Limestones, more massive than above; usual fossils ...	9	0
	[*Slight non-sequence*]		
Basement Bed			
truellei	Limestone, hard, white, locally somewhat argillaceous enclosing some pebbles and shells. The nether surface of the bed is uneven, the upper surface level, oyster-covered and bored:	4 to 0	6
	[*Great non-sequence*]		
Upper Lias	... ...	—	—

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CHAPTER IV

FULLERS' EARTH SERIES

By L. Richardson

IN the North Cotteswolds, the formations listed in the first column of the table on the opposite page come between the Clypeus Grit of the Inferior Oolite Series and the Taynton Stone of the Great Oolite. It is convenient, for the district under consideration, to group the whole of these deposits under the general term ' Fullers' Earth Series.'

ROUNDHILL CLAY

The Roundhill Clay extends eastward into the present district. It is up to about a foot in thickness and is to be observed in the Newhill Quarry, near Churchill Copse, Wychwood Forest (p. 19). It is also present near Ashford Cottages, to the south of Ashford Mill, but it is absent from Fawler.

CHIPPING NORTON LIMESTONE

This subdivision was included by Hull in his Lower Zone of the Great Oolite. It has a wide extent in the North Cotteswolds and about Chipping Norton and extends into this district. As a rule it is a somewhat hard, grey, oolitic limestone, locally brown and sandy, lime-coated and bedded, but weathering flaggy, especially at the top. There are occasional partings of shale, sometimes with ' marl,' and, in places, small well-rolled pebbles of limestone. Locally it is in part a sandy limestone that has been decalcified to a loose sand. Fragmentary plant-remains and shells, mostly oysters, occur.

The subdivision appears to have a considerable extent beneath the younger formations. At Stonesfield it is about 25 ft. thick, but to the east and north-east its upper part passes into White Sands, and its lower part into the Hook Norton Beds, which are brown sandstones, sandy limestones (' planking '), with brown sand and occasionally marly layers. Beneath Kirtlington the latter rest directly and non-sequentially on the Lias.

In the Furzey Hall boring (Sheet 235), 4 miles south by west of Burford (p. 40) a considerable part of the rock (estimated at 27 ft.) assigned to the Inferior Oolite may be Chipping Norton

FULLERS' EARTH SERIES

Moreton in Marsh area (Sheet 217) (a) North Cotteswolds	Witney area (Sheet 236) (b) Stonesfield	Witney area (Sheet 236) (c) Kirtlington
Rhynchonella-Bed and *Ostrea acuminata*-Limestone tentatively regarded as the top beds of the	Locally present up to about 1 ft.	No information, but certain of these deposits may be thinly represented
Stonesfield Slate Beds (a) Ragstone Beds (b) Slate Beds	6 ft.	
Fullers' Earth Clay (local)	—	
Upper Estuarine Clay Sharp's Hill Beds[1] (trace)	Locally present up to 4 ft. 6 in.	
Chipping Norton Limestone	About 25 ft.	White Sands: 16 ft. or so Hook Norton Beds: 16 ft. 9 in.
Roundhill Clay	—	

[1] Formerly Neaeran Beds. (*See* Arkell 1933, p. 298)

Limestone. " The Clypeus Grit was stated to have been passed through in the deep boring at the City Brewery, Oxford, but," according to Pringle (1926, p. 11), " an examination of the specimens from this borehole, preserved in the Survey collections, does not confirm the statement. The rock-specimens assigned to this horizon resemble more strongly certain beds of the Chipping Norton Limestone. Indeed, it is highly probable that the Inferior Oolite has been completely overlapped before reaching Oxford."

Details

In the drainage-basin of the River Evenlode there are old quarries in the Chipping Norton Limestone :—(1) south of Mount Pleasant a little over half-a-mile south-by-east of Shipton under Wychwood Church ; (2) south of the cross-roads a mile south-east by south of Shipton Church ; and (3) near a barn close to the Charlbury road about a mile east-south-east of Shipton Church. In the last, the rock is much disturbed, shattered, lime-coated, and locally reduced by decalcification to a loose sand. It has been worked recently in a small quarry on the south side of the Charlbury road half a mile east of Chilson of which a section is given below :

Jumpberry Corner Quarry, Chilson

	Ft.	Ins.
Chipping Norton Limestone		
Limestone, oolitic, flaggy : seen for	5	0
Marly rubble and limestone with well-rolled pebbles of limestone as at places in the North Cotteswolds	0	6
Marl, greenish, with films of limestone and brownish limestone with plant-remains	0	6
Limestone, massive, open-jointed : seen for ...	5	0

It is also seen :—(1) capping Newhill Quarry, near Churchill Copse, Wychwood Forest ; (2) in Buckleap Quarry, Cornbury Park ; (3) in the lane section at Topples Wood south of Fawler (p. 16) ; (4) in a small quarry near Ashford Cottages to the south of Ashford Mill ; (5) in the Ashford Mill railway-cutting (p. 27) ; (6) in the old ironstone working south-west of the road at Fawler ; (7) as loose pieces on the bank above the outcrop of the Clypeus Grit at the ford south of Stonesfield and (8) in an old quarry a quarter of a mile south of Hillbarn Farm to the north-west of Stonesfield. Our knowledge of the subdivision at Stonesfield is due to Walford (1906, p. 18) who derived some of his information from a shaft put down at Stockey Bank, Stonesfield (p. 32). The subdivision is well displayed in the large disused Buckleap Quarry (p. 26), where Welford (1906, p. 22) observed a thickness of 23 ft. without seeing its base. He picked up a fern, a Pecopterid probably, which he thought came from the lower part.

In the neighbourhood of Burford, the Chipping Norton Limestone is displayed in Dean Bottom Quarry, three-fifths of a mile north of Fulbrook Church. The rock varies even in the quarry face : in some parts it is light brown, sandy limestone with brown plant-remains, and in others, a beautifully oolitic limestone recalling Ketton Stone. A few pebbles of oolite were observed in the rock near the top, and the beds, as usual, are locally decalcified and lime-coated. There are other small quarries in similar rock (1) about 175 yds. east-by-south, and (2) about half a mile south-south-west of the above.

According to Hull (1857, pp. 58, 59) : " . . . east of Barrington [Sheet 235] we lose all trace of the Fullers' Earth, so that the basement beds of the Great Oolite rest upon the Ragstones of the Inferior Oolite. That this is the case is proved by the section of the south bank of the River Windrush opposite Swinbrook, where by means of a quarry close by the side of the lane which leads to the Oxford Road, and a cutting in the lane itself immediately underneath the quarry, we obtain a section in both formations." He gives a diagram and the following record in which the present author's insertions are enclosed in square brackets.

Section near Swinbrook

Great Oolite
  a. Clay or marl, with oysters, being the base of the upper zone of the Great Oolite.
  [Chipping Norton Limestone]
  b. Yellow sandy oolite, full of oblique lamination, and splitting into slabs; few or no fossils. Lower zone of Great Oolite.
Inferior Oolite
  [Clypeus Grit]
  c. Coarse-grained white oolite, rather rubbly with *Clypeus Plotii,* and *Terebratula globata.*

The clay *a* is probably a continuation of the soft limestone, largely made up of *Ostrea acuminata* J. Sowerby, and associated clays, seen in a small opening in the field to the west. The oysters demonstrate that the beds are not Hampen Marly Beds constituting the base of the upper zone of the Great Oolite, but a deposit between the Taynton Stone and the Chipping Norton Limestone. Hull's bed *b* is clearly Chipping Norton Limestone and his bed *c,* Clypeus Grit.

Some 7 feet of Chipping Norton Limestone overlain by bluish grey clay is well exposed in Nutoaks Quarry on the east side of the road a mile north of Swinbrook. The uppermost 18 ins. consists of brownish 'marl' with thin layers of limestone, locally much decalcified, and containing oysters and small pebbles of limestone. The rock below is more massive but in irregular beds, individually false-bedded, with bits of black and brown lignite, especially in the top layer in which there are also numerous clay-galls.

The only information concerning the subdivision in the north-eastern part of the district is derived from two borings at Kirtlington (Tiddeman, 1910, p. 57). One at The (Manor Farm) Buildings, just beyond the margin of Sheet 236 appears to prove a thickness of 16ft. 9 in. for the Hook Norton Beds and 16 ft. for the White Sands. In the Ardley-Fritwell railway cutting (Sheet 218) (Pringle *in* Arkell and others, 1933, pp. 346, 347), 5¾-miles to the north by east, the Hook Norton Beds are 19 ft. 6 in. thick (and rest on Upper Lias clay), and the White Sands 21 ft. thick. In the other boring at the Park, Kirtlington, 'dark sand' was reached at 135 ft. down.

SHARP'S HILL BEDS AND UPPER ESTUARINE CLAY

The Sharp's Hill Beds (Arkell 1933, p. 298), as the name implies, are typically developed at Sharp's Hill near Hook Norton in the Chipping Norton district. The majority of the constituent deposits are characterized by distinctive fossils, but all of them are seldom seen together and the individual layers are irregularly distributed even in the type area. The Upper Estuarine Clay has a wider distribution.

In the present district sections are few, and some of them are lacking in characteristic fossils; others are partly obscured, and the Buckleap Quarry section is dangerous of access. In the slate district of Stonesfield, at Stockey Bank (p. 32), Walford identified typical Sharp's Hill Beds, but in the shaft near Spratt's Barn, some 600 yds. away, they are wanting and the Stonesfield Slate rests directly on the Chipping Norton Limestone.

Details

Greenish, or grey, Upper Estuarine Clay is much in evidence on the high ground north-west of Waterloo Farm, Fulbrook.

At Nutoaks Quarry, on the east side of the road at 1¼-miles north-by-east of Swinbrook, the following section is exposed between 18 ins. of limestone representing the Stonesfield Slate above and 8½ ft. of Chipping Norton Limestone below.

Nutoaks Quarry, Swinbrook

	Ft.	In.
Upper Estuarine Clay (? all)		
Clay, tough, black and brown, ferruginous ...		4
Limestone, grey, fissile, sandy, in intermittent but locally large flagstone masses some of which have been used for walling hereabouts : 0 to	0	6
Clay, similar to clay below but darker	0	4
Level line of parting		
Clay, bluish grey	2	0

The following description of the Buckleap Quarry, half a mile south-west of Cornbury House is by Walford (1906, p. 22), who said that the rocks are "wholly Sub-Bathonian"; the classification given is by the present author, and the names of some of the fossils have been revised.

Buckleap Quarry

	Ft.
Taynton Stone	
1. Shattered limestone	10
2. Limestone	16
3. Limestone, marly; *Ostrea flabelloides* Lamarck, *Trigonia costata* J. Sowerby (large)	5
[*Stratigraphical position of Stonesfield Slate*]	
Upper Estuarine Clay and Sharp's Hill Beds	
4. Violet-black clay, ochreous sand and yellow marl with *Placunopsis*	5
5. Compact brownish limestone; *Nerinea, Mesospira leymeriei* (d'Archiac), *Trigonia, Neritodomus nuda* Piette, *Exelissa pulchra* (Lycett), *Corbula attenuata* Lycett, *C. buckmani* Lycett, *Cardium stricklandi* Morris & Lycett, *C. subtrigonum* Morris & Lycett	2
Chipping Norton Limestone	
6. Limestone, yellowish, a freestone of variable quality (in one course)	8
7. Marly limestone	4
8. Freestone in courses of 6 ft. and 5 ft., seen	11

The limestones are much disturbed, the joints having widened owing to slipping on the valley side and many masses are ready to fall. Bed 3 may contain in the lower part some representative of the coral bed, 7, of the Ashford Mill railway-cutting (*see below*). Bed 4 may be the equivalent of beds 3*a* and *b* of the author's record of the Bell Inn Quarry, Enstone, and *b* of Sharp's Hill (Richardson 1911, pp. 207, 219). Many of the fossils from bed 5 have a pinkish tinge like those in bed 14 of the Enstone Quarry.

Ashford Mill Railway-Cutting, near Stonesfield

	Ft.	In.
Taynton Stone		
8*a*, *b*, *c*. *a* and *c* : false-bedded, more or less fissile, broken-shell oolite, with an impersistent marly zone (*b*) of varying extent (3-5 ft.) some 2 ft. from the top. In the main mass of the bed		

	Ft.	In.
Taynton Stone—*continued*		
(*a*) were found abundant *Ostrea hebridica*, *Rhynchonella sp.* (unidentifiable fragments common), *Placunopsis socialis* Morris and Lycett, *Chlamys vagans* (J. de C. Sowerby), *Lima cardiiformis* (J. Sowerby), *Parallelodon* (*Beushausenia*) *transversum* (Morris and Lycett). [Tomes's beds 1-3] : seen	20	0
Stonesfield Slate Beds		
7. Coral and Rhynchonella Bed. At the western end of the cutting, bed 6 is succeeded abruptly, with a level upper surface, by a 3 ft. block of hard, white oolite, in places full of shells seen in section, and showing carbonaceous markings [Tomes's bed 4]. When traced eastward, first the lower part, and later the whole bed, becomes softer, passing into a dark-coloured, shelly, marly stone, a mass of large *Ostrea hebridica* and corals, especially *Thamnastraea lyelli* and *Isastraea limitata*, with numerous *Rhynchonella sp.* (smaller than and different from those in the Hampen Marly Beds). [Tomes's bed 5, from which he also recorded several other species of corals] : 2 ft. to ...	2	6
[*Approximate stratigraphical position of Stonesfield Slate*]		
Upper Estuarine Clay and Sharp's Hill Beds		
6. Black and greenish grey clay with an impersistent shaly layer (3 in.) composed almost entirely of *Placunopsis* and small forms of *Ostrea* of *acuminata* type [Tomes' bed 6] : 2 ft. to ...	3	0
5. Layer of the coral *Cyathopora bourgueti* Defrance, in perfect condition	0	2
4. Mussel Bed. Limestone, soft, yellowish, shelly, a mass of *Mytilus sublaevis* J. de C. Sowerby, with large nodules enclosing badly preserved corals. Also *Modiola imbricata* and *Parallelodon* (*Beushausenia*) *transversum* [Tomes's bed 7]	2	0
3. Marl, grey	0	6
2. *Nerinea-eudesii* Bed. Mudstone, hard, grey, flecked with small, angular, brown inclusions, passing down into a compact whitish to brown oolite, becoming softer towards the base ; the lower part crowded with *Nerinea eudesii* Morris and Lycett, *Aphanoptyxis tomesi* Arkell, and *Astarte angulata* Lycett, together with *Nerinea ashfordensis* Arkell and *Protocardia lingulata* (Morris and Lycett) [Tomes's bed 8] : 1 ft. to	2	0
Chipping Norton Limestone		
Limestone, massive blocks of compact, brown oolitic : seen to below rail-level in one place [Tomes's bed 9]	8	0

The first to describe this section was Gaudry (1853, p. 594), who visited it a year after the line was opened. He considered that the clays he recorded were Bradford Clay, and that since they underlie the Stonesfield Slate Beds, the latter must belong to the Cornbrash.

Woodward (1894, p. 318) gave a short description of the section and his account is repeated in the Oxford Memoir (Pringle, 1926, p. 19). A fuller and more accurate description was given by Tomes (1883, p. 171) who collected numerous corals. Both Tomes and Woodward agreed that the Stonesfield Slate lay below the level of the rails.

In 1906, Walford (1906, pp. 20, 21) identified the Bradford Clay of Gaudry with his Neaeran Beds and wrote: " My endeavour is to prove that the true Stonesfield Slate with *Trigonia impressa* lies above the two dark clay seams . . . There are *below* the Stonesfield Slate of the Stockey Bank boring [Stonesfield]."

In 1932, Arkell (1931, pp. 613, 615) described the section in detail and the above record is based on his account. As Arkell remarks, Walford's claim as to the Stonesfield Slate coming above the Neaeran Beds has been entirely substantiated by recent work. In his 1931 paper Arkell questions the precise position of the Stonesfield Slate as being between his beds 7 and 8, but in his 1933 work (p. 294) he places it between 6 and 7.

Walford (1906, p. 18) found his Neaeran Beds in the shaft at Stockey Bank, Stonesfield, the sinking of which he supervised (*see* p. 32). His description of the beds is as follows:

		Ft.	In.
" 23.	Black Clay crowded with *Placunopsis, Perna, Nucula* and *Ostrea*	1	7
24.	Shelly limestone made up of fragments of *Ostrea* passing into a brown limestone, blue-hearted, crowded with shells of *Perna quadrata, Cyprina, Corbula, Macrodon*	2	0
25.	Black Clay	0	11 "

Walford (1906, p. 14) states that bed 23 agrees with bed 6 of his Sharp's Hill record, i.e., the basal deposit of the present writer's Upper Estuarine Clay.

Stonesfield Slate Beds

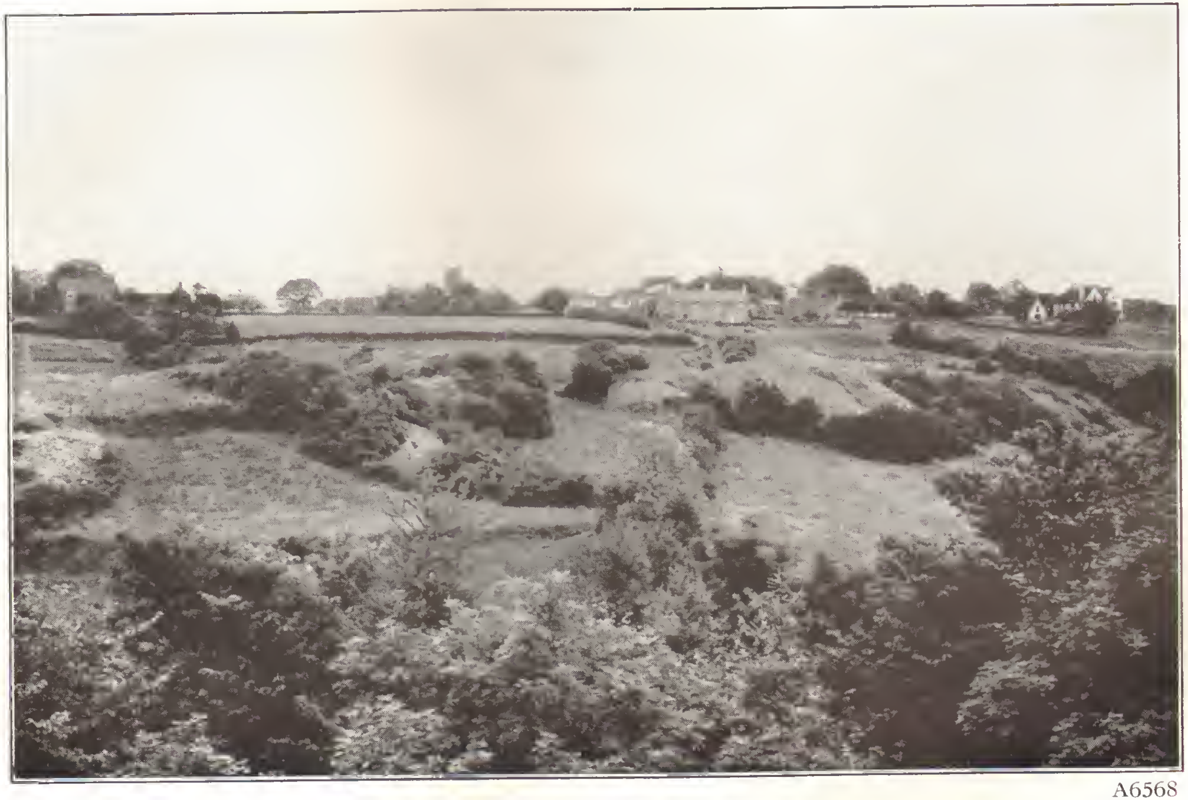
The Stonesfield Slate Beds consist of ' slate ' beds below and ragstone beds above. The individual beds are very irregularly developed and the true Stonesfield Slate or ' pendle ' is confined to the vicinity of Stonesfield.

In 1894 Woodward (1894, pp. 310-317) summarized the stratigraphy and palaeontology of the Stonesfield Slate. The reader is referred to that work for references to the literature dealing with the palaeontology, but certain excerpts from Arkell's (1933, pp. 296, 297) general account of the fauna and flora are appended.

" The fossils that have made the Stonesfield Slate famous the world over are the jaws and bones of small ancestral mammalia, occasionally found when the pits were in work. According to the latest reviser, Dr. G. G. Simpson, [1928, pp. 198, 199] there are known altogether four species belonging to four genera, classed as follows:

Multituberculata	*Stereognathus ooliticus* Charlesworth
Triconodonta	*Amphilestes broderipi* Owen
	Phascolotherium bucklandi (Broderip)
Pantotheria	*Amphitherium prevosti* (V. Meyer)

" Dr. Simpson writes that ' *Stereognathus* appears to be a last survivor of a group already found in the Rhaetic. The others as true mammals appear for the first time. . . . . .' "



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STONESFIELD VILLAGE AND WASTE HEAPS OF THE STONESFIELD SLATE WORKINGS, SEEN ACROSS THE VALLEY FROM STOCKEY BANK.

"The land fauna associated with the Stonesfield mammalia comprises two pterosaurs, *Megalosaurus bucklandi* (found also in the White Limestone and the Chipping Norton Limestone), and insects. The plants include ferns, cycads, conifers, and an undoubtedly dicotyledonous leaf, figured by Prof. Seward [1904, p. 152, Pl. xi, Figs. 5, 6]. . . . . ."

"There are remains of *Teleosaurus, Steneosaurus, Plesiosaurus*, a Chelonian, and about forty species of fish—including sharks, ganoids and a species of *Ceratodus*."

"Cephalopods are rare, but include *Gracilisphinctes gracilis* (J. Buckman), *Micromphalites micromphalus* (Phillips) (Buckman 1923, Pl. CDLIII), an unidentifiable species of *Clydoniceras* and *Nautilus baberi* (Morris and Lycett). Long lists of lamellibranchs and gastropods have been published, but the only really abundant and characteristic species are *Trigonia impressa* (J. de C. Sowerby), *Gervillia ovata* (J. de C. Sowerby), *Ostrea acuminata* (J. Sowerby) and *O. sowerbyi* (Morris and Lycett) [*hebridica* Forbes], with crushed Rhynchonellids and numerous specimens of *Chlamys* and *Camptonectes* of the common Great Oolite species."

In the 'Details' that follow, in addition to particulars of the Stonesfield Slate, it is convenient to give those of the underlying Chipping Norton Limestone, etc., and the overlying Taynton Stone, Hampen Marly Beds and White Limestone of the Stonesfield area.

Details

"The Rhynchonella and the stratigraphical position" of the Rhynchonella Bed in the Ashford Mill railway-cutting, as remarked by Arkell (1933, p. 294) "indicate that this is the Sevenhampton Rhynchonella Bed of the Cotteswolds, and the top of the clays beneath contain true *Ostrea acuminata*".

The rocks near the ford south of Stonesfield are disturbed, but the little river-side cliff imperfectly displays:

	In.
Rhynchonella Bed. Marl; *Kallirhynchia sp.*	
Clay, greenish black; about	4
Ostrea acuminata Limestone; small *Ostrea acuminata* J. Sowerby and abundant *Placunopsis socialis* Morris and Lycett.	2
Clay, yellow marly: about	3
Chipping Norton Limestone	
Limestone, disturbed, lime-coated.	

As already pointed out (p. 28), Sharp's Hill Beds are present in Stockey Bank but, locally, the Slate Beds alone intervene between the Taynton Stone and Chipping Norton Limestone. This may be seen from Fitton's record (1828, p. 412).

Sequence at Stonesfield

		Ft.
	[White Limestone]	
d	Rubbly limestone	32
	[Hampen Marly Beds]	
	Clay with Terebratulites	
	Limestone	
	Blue clay	
	Oolite	
c	Blue clay	
	[Taynton Stone]	
b	‘Rag’, consisting of shelly oolite, with casts of	
	[Stonesfield Slate Beds]	
	bivalves and univalves, about	25
a	‘Soft stuff’, yellowish sandy clay, with thin courses of fibrous transparent gypsum ...	½
	‘Upper Head’, sand enveloping a course of spheroidal laminated calcareous gritstones which produce the slate. These are called ‘Potlids’, from their figure, and receive with the other slaty bed the name of ‘Pendle’, as characteristic of the workable stone. The stone is partially oolitic and shelly, sometimes full of small fragmentary masses ...	1¼ to 1½
	‘Manure’ or ‘Race’, slaty friable grit rock ...	1
	‘Lower Head’, sand and grit, including a course of spheroidal concretions of slate, as above	1½ to 2
	‘Bottom stuff’, sandy and calcareous grit, with admixture of oolitic grains	1
	Chipping Norton Limestone	

Confirmatory information was obtained in 1933 when Mr. George Poole of Stonesfield told the present author that in the last-worked shaft at Spratt's Barn (*see* p. 134) the ‘Pendle’ rests directly on ‘rock’ (Chipping Norton Limestone), there being no clay between.

The Slate Beds are seen in the Hampen railway-cutting between Notgrove and Andoversford in the Cotteswolds (Sheet 217) with the Ragstone Beds, *Ostrea acuminata* Limestone, Rhynchonella Bed and Taynton Stone in ascending sequence above. Near by on Salperton Downs the Slate Beds were exposed in a quarry and these are, both lithically and palaeontologically, identical with those at Stonesfield. The ‘Upper Head’ at Stonesfield, as pointed out by Fitton, contains pebbles of limestone: identical pebbles occur in the corresponding bed on Salperton Downs. The stratigraphical position of the Stonesfield Slate Bed is thus evident, but this matter is referred to again later (p. 31) after certain higher beds in the vicinity have been noticed.

There is ample evidence of typical White Limestone in the locality. The well at Stonesfield Rectory, sunk in 1931, went through 22 ft. of this rock to clay—doubtless Hampen Marly Beds. These, hereabouts, contain two main beds of clay: blue clay, certain of the marly layers in which are replete with *Ostrea hebridica* Forbes, is seen in the bank alongside the lane leading from the village to the ford. Taynton Stone is exposed below in the bed of the lane and in the bank on the left: it contains a number of marly layers, one with *Pseudotrapezium* fairly common and occasional specimens of *Natica;* others with ‘*Rhynchonella* cf. *concinna*’ (J. Sowerby)—especially a layer which appears to occur in the basal portion. This has long been a favourite collecting spot.

About 15 ft. of Taynton Stone is exposed in a cutting through which the old Roman road, the Akeman Street, passes a little to the north-west of the ford. The rock is oolitic and flaggy as in the Ashford Mill railway-cutting and contains specimens of the usual flat rhynchonellid.

The Hampen Marly Beds are also seen near the top of Stockey Bank—the steep western side of the valley one-third of a mile south-west of Stonesfield Church:

	Ft.
Alternations of pale yellow and brownish marl and soft marly limestone with *Ostrea hebridica* Forbes abundant, especially in the lowest 1 ft. 6 in., and large '*Rhynchonella concinna*' (J. Sowerby) abundant throughout: seen	6
Marly limestone (locally very oolitic) and marl alternating, the whole weathering crumbly: seen	10

In the Whitehill Wood railway-cutting, about a mile south of Stonesfield, 21 ft. 3 in. of the Hampen Marly Beds are exposed; the probable thickness hereabouts is 25 ft. The Taynton Stone is about 25 ft. thick; the Slate Beds from 0 to 6 ft.; the Sharp's Hill Beds, 0 to 4 ft. 6 in.; and Chipping Norton Limestone about 25 ft.—total 75 ft. to 84 ft. 6 in.

A well with a boring was sunk in 1928 at the Manor House (the old rectory) by Messrs. Allsebrook and Co., of Reading, who have supplied the following particulars; the classification has been inserted by the author.

Manor House Boring, Stonesfield

		Thickness Ft.	Depth Ft.
Well (*dug*):			
White Limestone	Stone	35	35
Hampen Marly Beds (upper part)	Clay	2	37
	Stone	8	45
	Clay	2	47
H.M.B. (lower part), Taynton Stone Stonesfield Slate Chipping Norton L.	Stone	74⅓	121⅓
Borehole:			
Clypeus Grit. Light grey rock (fairly soft cutting)		28½	149⅚
Upper Lias. Blue clay		9½	159⅓
Middle Lias. Rock, soft and hard bands and seams of green sand		11½	170⅚

It is now necessary to revert to the matter of the stratigraphical position of the Stonesfield Slate.

Fitton's section shows the Slate in the stratigraphical position in which it would be placed on evidence obtainable in the Cotteswold Hills, namely, below the Taynton Stone. Three geologists, however, namely Hull, Woodward and Walford have all recorded particulars which would lead one to understand that the Slate Beds occur at or near the top of the Taynton Stone. The top part of the Taynton Stone is locally fissile, but there should be no confusion of tile-stones from this horizon (if any have ever been obtained) with Stonesfield slates—fossils would settle the matter. However, particulars obtained by the geologists named are repeated below.

Shortly after the Marlstone iron-ore was discovered at Fawler in February, 1859, the Duke of Marlborough wished to ascertain the depth at which it occurred beneath the slate of Stonesfield. Accordingly he had a shaft deepened at Reed Hill on the east side of the valley between Fawler and Hillbarn Farm, but when the sinking reached the Upper Lias clay the influx of water was so great that it had to be abandoned. Hull, (1860, p. 304) gave the following record of the rocks that were penetrated:

Reed Hill Shaft, Stonesfield

		Ft.
Great Oolite		
Upper Zone.—White limestone resting on calcareous shales and marl with *Ostrea sowerbyi* [? *hebridica*]		10
Lower Zone.—Sandy flags, slates and shelly oolite with a band of 'Stonesfield Slate' at 10 ft. from the top. *Trigonia impressa*, etc.		80
Inferior Oolite		
Upper Ragstone or zone of *Am. parkinsoni* (Wright)	Coarse-grained rubbly oolite with *Clypeus ploti*, *Lima gibbosa*, *Trigonia costata*, etc.	30
Upper Lias		

The particulars do not mention any beds that might have been interpreted as Sharp's Hill Beds, but they are sufficient to suggest that Hull placed the Stonesfield Slate near the top of what would now be classed as Taynton Stone.

Woodward's observations (1894, p. 310) seem to confirm Hull's: he says, "The only partially open working that I have seen, was situated at Red [Reed] Hill . . . Here the slate was exposed, although worked underground in the hillside. The following section was shown:

			Ft.	In.
Great Oolite (Lower Division)	"Alternations of oolitic limestone and marl		3	0
	Marl with thin films of sandy limestone: *Pecten vagans* and '*Rhynchonella concinna*'		6	0
	Roof Bed: grey oolitic and sandy limestone (that does not split and is of no use)		2	0
	Stonesfield Beds	Shaly bed	0	6
		Stone worked for 'slate'—grey sandy and oolitic limestone	1	0
		Shaly bed"		

The top bed may be basal Taynton Stone and the underlying 6-ft. bed may include a representative of the *Ostrea acuminata* Limestones and associated clays seen at certain localities in the Cotteswold Hills and tentatively referred to the top part of the Stonesfield Slate Beds.

In 1893, Walford obtained the assistance of the British Association for sinking a shaft with the object of determining the nature of the 70 ft. of Great Oolite beds which Hull had recorded as intervening between the Slate and Inferior Oolite (Clypeus Grit) at Reed Hill Shaft (Walford 1894-6). He had the upper part of the steep valley side known as Stockey Bank scarped for 33 ft. and then a shaft sunk (so as to give a continuous section), ultimately to a depth of 60 ft. He records the Slate Beds in a similar position to that noted by Hull and Woodward—immediately beneath marly beds. The writer, in company with Arkell, has investigated the spot: Hampen Marly Beds are still clearly exposed (*see* p. 31), but no trace of Stonesfield Slate was detected.

The sinking supervised by Walford has furnished some valuable information, especially as regards his Neaeran (now Upper Estuarine Clay together with Sharp's Hill Beds), but he was not entirely satisfied with the results of the exploration as the following statement in his 1896 or Final Report to the Association demonstrates: "owing to the faulted state of the bank," "the greater part of beds Nos, 18 to 26 have to be excised from the list." In 1906, however, he (1906, pp. 17-20) revised his opinion that beds 18 to 26 had been misplaced and reproduced the record given in the 1895 Report with some condensation.

There is no information concerning the beds between the White Sands (i.e. the upper part of the Chipping Norton Limestone) and Taynton Stone below ground in the north-eastern part of the district, but in the Ardley-Fritwell railway-cutting some seven miles north-by-east of Bletchingdon Station the intervening beds are displayed (Arkell and others, 1933, p. 346) and it may be assumed that beneath Bletchingdon they are similar.

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CHAPTER V

GREAT OOLITE AND ‘ FOREST MARBLE ’

By L. Richardson

THE subdivisions of the Great Oolite are set out in the second column in the table on page 72. The Stonesfield Slate Beds are usually included in the Great Oolite but in this memoir they have been classed with the Fullers’ Earth Series.

TAYNTON STONE

The Taynton Stone is well developed in this district and has been extensively worked in the neighbourhood of Burford (*see* p. 132). It consists of whitish, false-bedded, more or less fissile, broken-shell oolite that weathers yellowish. There are occasional softer layers, in places marly. In the neighbourhood of Stonesfield it is in part sandy and weathers somewhat browner. Its maximum thickness is 25 ft. It is well exposed in the Milton Quarries (8 ft. 2 in. +); Swinbrook Quarry (14 ft. +) (p. 35); Buckleap Quarry, half a mile south-west of Cornbury House (23 ft. +); Ashford Mill railway-cutting (20 ft. +) (p. 26); Whitehill Wood railway-cutting, south of Stonesfield (12 ft. +) (p. 35); and the quarry near Westfield Farm, Combe (12 ft. +). Frequently its top part is markedly flaggy and fissile as in the cutting through which the Akeman Street passes near the ford south of Stonesfield.

HAMPEN MARLY BEDS

The Hampen Marly Beds are well exposed with the Taynton Stone below and the White Limestone above in the Hampen railway-cutting west of Notgrove in the North Cotteswolds (Sheet 217). They extend into the present district, in which they are well developed, and thence north-eastwards into southern Northamptonshire, where they are known as the Upper Estuarine Limestones or Rhynchonella Beds. In the present district, as elsewhere, certain of the constituent deposits are crowded with large specimens of ‘ *Rhynchonella concinna* ’ J. Sowerby (the type is said to have come from the Hampen Marly Beds of the Allotments’ Quarry, Aynho, 6 miles south-east of

Banbury) and *Ostrea hebridica* Forbes (*Ostrea sowerbyi* Morris and Lycett; *see* Arkell 1934, p. 29). The beds attain a maximum thickness of about 25 ft. and are admirably displayed in the Milton Quarries (17 ft. 4in.), Whitehill Wood railway-cutting, south of Stonesfield (21 ft. 3 in. +), and Swinbrook Quarry (19 ft. 6 in.), and are indifferently exposed at several other localities mentioned below. They are of some importance from a water-supply standpoint for their clayey beds throw out a number of important springs from the base of the succeeding White Limestone.

Details

In the section at the Milton Quarries the whole of the Hampen Marly Beds, 17 ft. 4in. thick, is displayed, with the Taynton Stone below and the White Limestone above (*see* Richardson 1910).

The abandoned quarry at Swinbrook has been referred to by Hull (1857, pp. 55, 56) and Arkell (1933a, p. 292) and described in detail by Woodward (1894, p. 305).

Swinbrook Quarry

	Ft.	In.
White Limestone		
Limestone, white, much broken: seen for ...	2	0
Hampen Marly Beds		
Marl, clayey, green and brown	1	0
Marl, buff, indurated and fossiliferous along the median portion; *Ostrea hebridica* Forbes ...	1	0
Limestone, marly—a prominent bed	2	10
Marl, brown, grey and white	1	4
Marl, buff, indurated	2	0
Marl, buff	5	4
Marl, white	2	4
Limestone, grey, oolitic, locally laminated with an intervening layer of brown marl. Usually a prominent bed but locally a marl; '*Rhynchonella concinna*' J. Sowerby, rare	1	8
Marl, grey to buff, locally oolitic	2	0
Taynton Stone		
Freestone: seen	14	0

Hampen Marly Beds, with abundant large specimens of '*Rhynchonella concinna*' and *Ostrea hebridica* are imperfectly exposed in the west side of the valley south of Potter's Hill, west of Leafield.

The following section, seen in the railway-cutting south of Stonesfield, has been described by Arkell (1931, pp. 612, 613).

Whitehill Wood Railway Cutting

	Ft.	In.
Hampen Marly Beds		
Marls, grey, brownish and buff (mainly overgrown): seen for	5	0
Rhynchonella and Ostrea Beds:—*a*. Marl, crowded with large '*Rhynchonella concinna*' and *Ostrea hebridica*	3	0
b. Limestone, soft, white, marly, sparsely oolitic, with rhynchonellids and badly preserved casts of lamellibranchs	1	0
c. Marl, crowded with '*Rhynchonella concinna*' and *Ostrea hebridica*	1	3

	Ft.	In.
Limestone, laminated, oolitic		6
Marl, brownish and buff, the lower part irregularly hardened and in places merging into the underlying bed	3	0
Limestone, false-bedded like Taynton Stone, full of comminuted shells—a prominent bed ...	2	6
Marl, marly clay, and soft marly limestone. At the north-western end of the cutting this has at the top a 1-foot band crowded with large *Ostrea hebridica* and '*Rhynchonella concinna*'; *Chlamys vagans* (J. de C. Sowerby), *Trigonia pullus* J. de C. Sowerby, etc. At the other end of the cutting it divides into :— *a*. Yellow marl with *Ostrea hebridica* and *Clypeus muelleri* Wright ... ... 1 ft. *b*. Soft, crumbly, oolitic, marly limestone 1 ft. *c*. Marly Clay ... ... 3 ft.	5	0
Taynton Stone		
Thick beds of false-bedded, white, rather fissile, broken-shell limestone, with softer bands: seen for	12	0

About a quarter of a mile to the east, north of the railway and near Westfield Farm is a quarry in which 6 ft. of Hampen Marly Beds, containing specimens of '*Rhynchonella concinna*' and *Ostrea hebridica* to the base, are seen resting on 11 ft. of Taynton Stone (Arkell, 1931, p. 613; Pringle, 1926, p. 20). The Beds are also exposed at Stockey Bank, Stonesfield (p. 31).

White Limestone and 'Forest Marble'

Hull (1857, p. 68), who carried out the original geological survey, mapped all the rocks between the White Limestone (Great Oolite) and Cornbrash as Forest Marble. His mapping (with minor rectifications) has been adhered to. The White Limestone and Forest Marble were identified by him in the quarry now known as the Minster Lovell War Memorial Quarry (p. 46). Since his time, however, it has been ascertained that whereas in the neighbourhood of Kemble in the Cotteswolds the Bradford Clay rests on limestones of Great Oolite facies (that have been claimed by some as Great Oolite and by others as Forest Marble), in the Witney District it rests on beds of the facies of Forest Marble, and that the beds of predominantly Great Oolite facies in the Kemble area pass laterally into beds of predominantly Forest Marble facies in the Witney District (*see* Arkell 1931, pp. 593-595; 1933*a*, p. 288; Richardson 1935, p. 403). The 'Forest Marble' shown on the New Series map, Sheet 236, therefore, is divisible into two parts :—(1) an upper, with the Bradford Clay characterized by *Digonella* (formerly *Ornithella;* see Muir-Wood 1934, p. 550) *digona* (J. Sowerby) at the base, known as the 'Wychwood Beds,' and (1) a lower, known as the 'Kemble Beds.'

WHITE LIMESTONE

The White Limestone subdivision is about 52 ft. thick in the neighbourhood of Hanborough and Woodstock. Speaking generally, it consists of cream-coloured oolite and beds of hard white, but usually blue-hearted, lithographic limestone, with beds of clay at various horizons. Locally, the hard beds are composed of roundish, subangular and ramose 'lumps' of white lithographic limestone enclosed in a softer yellowish oolite. Such beds throw light on the origin of the Dagham Stone of the neighbourhoods of Cirencester and Tetbury and support the view that the cavities of the Dagham Stone are mostly due to the removal of softer oolitic parts (*see* Richardson 1933, p. 48).

The writer has for many years endeavoured to find, in the Great Oolite of the Cotteswolds, fossils that are sufficiently restricted in vertical range to be of use in zoning, but, while progress has been made, results have not as yet come up to the desired requirements. In the Witney district, where there are better and more numerous sections, Arkell has accomplished valuable zonal work. He has relied mainly on epithyrids and gastropods. The epithyrids, by themselves, owing to their mutability and range, are unreliable for the purpose of extensive correlation. In this district they occur in profusion at three horizons:—the Upper *Epithyris* Bed in the Kemble Beds, the Middle *Epithyris* Bed, and the Lower *Epithyris* Bed, but in the last, which is much thicker than the other two, they may be found in abundance either throughout the unit or in the top or bottom part only, or be absent altogether.

The gastropods prove more satisfactory: three horizons noted, in descending order, are characterized by an abundance of:—

Aphanoptyxis bladonensis Arkell,
Aphanoptyxis ardleyensis Arkell,
Nerinea eudesii Morris and Lycett,

while *Ptygmatis bacillus* (d'Orbigny) marks a horizon in either the bottom part of the *Nerinea eudesii* Beds or just below. *A. bladonensis* ranges upwards into the Kemble Beds: *A. ardleyensis* is the most useful zonal index of the four.

The order of the epithyrid and gastropod zones, in descending sequence, is:—

Upper *Epithyris* Bed
Aphanoptyxis bladonensis Bed
Middle *Epithyris* Bed
Aphanoptyxis ardleyensis Bed
Nerinea eudesii Morris and Lycett,

Arkell (1931, p. 566; 1933*a*, pp. 289, 291) has separated the upper beds included in this memoir in the White Limestone and named them the '*Fimbriata-waltoni* Beds' on account of their containing in abundance *Astarte fimbriata* Lycett and *Gervillia waltoni* Lycett, and considers them to be a distinct subdivision between the White Limestone and Kemble Beds. As regards the lower limit of the *Fimbriata-waltoni* Beds, while the Middle

Epithyris Bed does not contain the *fimbriata-waltoni* fauna there are frequently indications that it rests on an eroded surface of the white limestone below, and since it is too thin to be regarded as a separate entity, it may be taken provisionally as the basal deposit of the *Fimbriata-waltoni* Beds.

Sections of the lower part of the White Limestone are not numerous. The best are in the Milton (p. 35), Eton College (p. 48) and Layshillwood (p. 57) quarries. It has not been found possible as yet to zone the lower beds, but *Clypeus muelleri* Wright is a notable fossil, and in this district is rarely found in the higher beds. In the Layshillwood Quarry the lowest stratum seen, which is at or near the base of the White Limestone, is a very hard white, blue-hearted, lithographic limestone, with abundant corals and small epithyrids. Resting on it is a bed of tough clay that is worthy of note, since judging by the Milton Quarries section, clay beds locally increase in number in the lower part of the subdivision and thicken at the expense of the limestones.

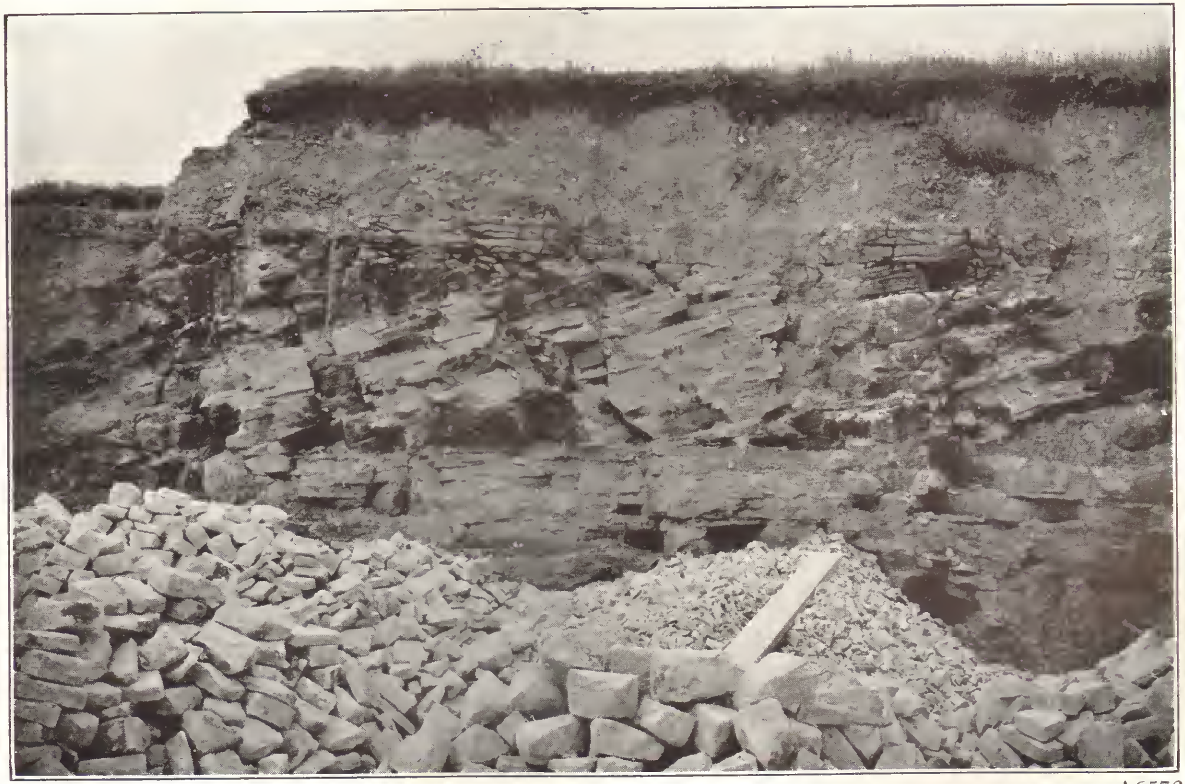
KEMBLE BEDS

The Kemble Beds are of diverse lithic characters: visits to a few well-separated quarries give the impression that the layers are very impersistent, but systematic work reveals that they are continuous over fairly wide areas. The top part is locally sufficiently calcareous to have gained the name of ' strong lime.' Below, in descending order, come sandy limestones, very distinctive oolite, blue grey when freshly quarried and largely composed of comminuted oysters in a calcitic matrix; flagstones, which are sandy and often liberally ripple-marked; and locally, at the base, beds with abundant large oysters.

A point that was apparently not appreciated by Hull is that White Limestone facies is extensively developed in the Kemble Beds with the result that in one or two places he has Kemble Beds in the White Limestone.

In the neighbourhood of Witney and in the north-eastern part of the district under review, the rock at the base of the subdivision if seen by itself in a small exposure would, no doubt, be identified as White Limestone, but in the quarry of the Oxford Portland Cement Works at Shipton on Cherwell it can be seen passing laterally into rock of ' Forest Marble ' facies. This basement bed is usually packed with epithyrids and corals (Upper *Epithyris* Bed). At other localities a similar epithyrid-coral bed is developed at other positions in the Kemble Beds, *e.g.*, in the new East End Quarry, North Leigh (p. 56) in the median part, and in Dogslade Quarry, Wychwood Forest (p. 51) at or near the top.

In the neighbourhood of Gibraltar, Bletchingdon, a considerable part of the Kemble Beds (but not the Upper *Epithyris* Bed) passes laterally into clay, and the same appears to be the case, but to a greater extent, in the Hanborough railway-station cutting.



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FALSE-BEDDED LIMESTONE, HANBOROUGH STATION QUARRY.
The false-bedded limestone belongs to the Kemble Beds, which are succeeded by clay (belonging probably to the Wychwood Beds), and this by traces of Cornbrash.

There is evidence (pp. 52-54) that there is a slight intra-subdivisional non-sequence in the upper part of the Kemble Beds.

The frequent false-bedded nature of the beds and the appearance of a similar epithyrid-coral bed at the base, in the median part, and at the top, point to their having been of comparatively rapid accumulation.

For mapping purposes, as already remarked, the Kemble Beds are included in the Forest Marble. The epithyrid-coral bed of the Cherwell Valley, therefore, comes in ' Forest Marble ' ground. In the Oxford memoir (Pringle 1926, p. 24) the lower limit of the Forest Marble was carried down to take in the *Ceteosaurus* Clay and Middle *Epithyris* Bed. In the present memoir this clay is classed with the White Limestone. In the greater part of Viner's Quarry, Kirtlington (p. 68) it is on an average 3 ft. 9 in. thick, but in the north-western part of that quarry it is represented by a layer of green clay about three inches thick and similar to the green clay layer, bed 2, in the Eton College Quarry, Asthall (p. 48). While in the Cherwell Valley the *Ceteosaurus* Clay lies on top of White Limestone, similar clays appear at one or more levels in the upper part of the White Limestone at a number of other localities : it may be that the *Ceteosaurus* Clay is to the south-westward split up by the intra-formational development of white limestone, for example of *Aphanoptyxis bladonensis* date (*Cf*. Hull 1859, p. 20).

Wychwood Beds

In the Witney district the Wychwood Beds vary much in thickness from place to place, ranging from 0 to 27 ft. As a rule they are mostly clay, but in the neighbourhoods of Witney and Bladon, near Woodstock, limestones of typical Forest Marble type are prominently developed.

The Wychwood Beds are easier to identify in the Witney area than in the Cirencester area, because, whereas in the latter district specimens of *Digonella digona*, etc., which characterize the basal clay, have been recorded from only two exposures at Cirencester and Kemble, in the present district, they have been recorded from several localities. *D. digona* is to be found in profusion in the quarry south-west of Carterton cross-roads (p. 42), in that half-mile west by south of Shilton Church (p. 42), and in clay dug out of Tweed's Well, Carterton (p. 41), is to be procured at North End Quarry, Carterton (p. 41), and has been recorded from Witney (p. 44) and the famous Islip Quarry in the north-eastern part of the district. On the evidence of fossils known to be the associates of *D. digona*, the Bradford Clay has been identified in the Spinney Quarry, Bladon (p. 63); there is evidence for concluding that it is represented at Capps Lodge Quarry, near Burford (p. 54), and Woodward appears to have seen it on the outskirts of Burford (p. 50).

Details

A quarry, two-thirds of a mile north by east of Kencott Church, known as 'The Pit,' has been long abandoned, but in the face may still be made out rubbly Cornbrash (2 ft.), Wychwood Beds clay (6 ft.), and Kemble Beds (seen 5 ft. 6 in.), the top layer of which is a 'lumpy' limestone with bits of wood and oysters resembling Cornbrash, but differing in being markedly oolitic.

The Kemble Beds are better exposed in a small quarry 'in work' about 250 yds. to the north.

Quarry near The Pit, Kencott

	Ft.	In.
Wychwood Beds		
1. Clay, brown and greenish brown: seen for ...	1	0
2. Limestone, grey, sparsely oolitic, in thin layers with partings of brownish marl and flakes of limestone. In the median part small oysters are abundant	2	0
Kemble Beds		
3. Limestone, grey, with scattered large white ooliths and *Ostrea hebridica* Forbes. Locally false-bedded, in the upper part weathering into small tabular pieces; more regularly bedded in the lower part, which yields some large irregularly-surfaced flagstones slightly sandy: seen for...	6	6

The surfaces of some of the flagstones are covered with rhynchonellids; of others, with problematical markings resembling a large flat-valved lamellibranch up to 7 in. across. The latter are also abundant in similar beds on the same horizon in the Upper Greenhill Quarry, Bletchingdon (p. 67).

At 1⅔ mile north-by-west of Kencott Church, close to a barn on the west side of the road, is a disused quarry which shows up to 4 ft. of clay belonging to the Wychwood Beds, overlying some 8 ft. of brownish oolitic limestone, the upper half of which (above a marl parting 0 to 4 in. thick) is markedly false-bedded. The limestone has to some extent the character of a Great Oolite facies.

At Furzey Hall, Filkins (Sheet 235), to the west of the fourth milestone from Burford on the Burford-Lechlade road, a boring was made in 1934 by Messrs. C. J. Elland & Sons, Luton. It commenced 345 ft. above Ordnance Datum and proved the following sequence:—

Furzey Hall Boring, Filkins

		Thickness	Depth
		Ft.	Ft.
Cornbrash		4	4
Wychwood Beds. 'Light and blue clay' ...		27	31
Great Oolite	Kemble Beds. 'Forest Marble' ...	21	52
	Great Oolite: estimated	117	169
Inferior Oolite: estimated		27	196
Upper Lias: penetrated...			

The section gives the thicknesses of the Wychwood and Kemble Beds, but it demonstrates how extremely variable is the thickness of the former within even short distances. The estimated thicknesses are by Pringle, who visited the boring. Incidentally, the top of the Upper Lias is 105 ft. 10 in. lower here than at Burford Signet.

Oolitic, flaggy, false-bedded Kemble Beds of incipient Forest Marble facies are exposed to a depth of 15 ft. in a quarry on the east side of the road east of Field Farm. Arkell (1931, p. 593) records that some of the beds are crowded with *Eocallista sp.*, *Navicula* (*Eonavicula*) *gibbosa* (Rollier), etc., and that "Bands of clay are intercalated, and at the top are 2½ feet of clay, probably a relic of the Bradfordian. The same beds were described by Woodward (1894, pp. 371, 372) in mistake for Forest Marble in a long line of old excavations west of Rock Farm, Carterton."

On the west side of the road about two-thirds of a mile south-east of Shilton is a quarry that may be called ' North End Quarry, Carterton.'

North End Quarry, Carterton

	Ft.	In.
Wychwood Beds		
1. Clay, traces up to	0	6
2. Limestone, typical ' Forest Marble,' thinly flaggy ; *Ostrea hebridica* Forbes	1	2
3. Clay, grey...	2	0
4. Limestone, as above ; full of fossils—polyzoa, pectens, *Rhactorhynchia obsoleta* (Dav.) etc.	0	4
5. Clay, grey ; *Digonella digona* (J. Sowerby) abundant in the median part, but here the principal Bradford Fossil Bed is at the base and contains *D. digona* (one specimen of which was found adherent to the surface of the Kemble Beds), *Rhynchonelloidea curvivarians* Buckman, *Avonothyris sp.*, and *Ostrea hebridica* Forbes (some with *Webbina* attached)	2	6
Kemble Beds		
6. Limestone, grey, oolitic, flaggy, locally false-bedded : seen for	4	0

A well, 9 ft. deep, at the bungalow in the quarry, is said to go through similar Kemble Beds, with an irregular bed of blue clay, to ' hard rock ' (?White Limestone), which constitutes the bottom of the well.

Two facts obtained from a study of this section are important: (1) *Digonella digona* occurs down to the bottom of the clay 5, and (2) in one part of the quarry greenish clay, up to 1 ft. in thickness, is seen resting on Kemble Beds. If this part of the quarry had been the only opening, while it might have been suspected that the clay was Bradford Clay, the other part proves that such is the case and makes it legitimate to assume that similar clay seen resting on Kemble Beds at other sections in this neighbourhood is Bradford Clay.

About three-quarters of a mile south of the last quarry, Tweed's well was sunk in a field on the north side of the road opposite Messrs. T. Blackwell and Son, Builders.

Tweed's Well, Carterton

	Ft.
Soil	1
Cornbrash	
1. Obovata Zone. Limestone, light reddish weathering, very hard ; *Obothyris obovata* (J. Sowerby), *Pseudomonotis echinata* (W. Smith), *Trigonia angulata* J. de C. Sowerby	6
Wychwood Beds	
2. Clay, yellow	6
3. Limestone, very light grey, very hard, in two layers with a clay parting ; abundant *Ostrea hebridica* Forbes	1½
4. Clay, hard, blue ; abundant *Digonella digona* (J. Sowerby) and rhynchonellids : penetrated ...	13

General information was given by the well-sinker : details were obtained from an examination of the tip. The well must reach nearly to the Kemble Beds. The 1½ ft. bed of limestone is spoken of locally when encountered in wells, as being 'a very hard blue rock that takes a good polish.' The specimens of brachiopods from the 13-ft. bed of clay were picked up loose: it is not known if they occur distributed throughout the bed, but the evidence of neighbouring sections is that they come from the lower part.

While, as a rule, in Carterton and neighbourhood, clay parts Cornbrash from Kemble Beds, Hull (1857, pp. 73, 74) noticed Cornbrash resting directly on 'white fine-grained oolitic freestone, obliquely laminated,' exposed to a depth of 10 ft., and doubtless Kemble Beds, 'in some quarries opposite Alvescott Down Farm.' He remarked that this was exceptional as blue clay intervened to the north and there were intervening beds present in the road-cutting to the south of Rock Farm.

A quarry in a spinney north of the road and 300 yds. west of Shill Brook is described by Arkell (1931, p. 592) as follows:—

Quarry south-west of Carterton Cross-Roads

	Ft.
Wychwood Beds	
1. Clay, buff: seen for	3
2. Bradford Fossil Bed. Limestone, argillaceous, hard in centre, marly above and below; abundant *Digonella digona* (J. Sowerby); with *Rhactorhynchia obsoleta* (Davidson), *Dictyothyris coarctata* (Parkinson), *Modiola imbricata* J. Sowerby	1
3. Clay, buff to grey, with some *Ostrea hebridica* Forbes at the base	3
Kemble Beds	
4. Limestone, grey, coarsely but sparsely oolitic, false-bedded, with shell-fragments, becoming finer grained and more compact below: seen to	5

To the north of this pit the Kemble Beds are displayed in a quarry north of the road and on the east bank of Shill Brook, where they are for the most part white oolitic limestone, locally false-bedded, with layers of oolitic marl with scattered oysters. Seams of clay are more in evidence in the upper part, where the associated limestone approaches the Forest Marble facies with oysters.

At the cross-roads a third of a mile west-by-north of Shield Farm, Alvescot, is an old quarry that displays, poorly, Wychwood Beds overlying Kemble Beds. A thin limestone in the clay, that occupies approximately the same stratigraphical position as the Bradford Fossil Bed of the quarry south-west of Carterton cross-roads, contains *Actaeonina luidii* Morris in some abundance (*see also* p. 57).

Near a barn, at the road fork, half a mile west-by-south of Shilton Church is a small quarry in which the Bradford Fossil Bed (0 to 6 in. thick), extremely rich in *Digonella digona* and containing an occasional *Rhactorhynchia obsoleta,* is seen resting directly on Kemble Beds. This will be the "pit to the south-west of Shilton" in which Woodward (1894, p. 371) found "an indication of the Bradford Clay."

In the field west of Woodside Farm, Shilton, is a small quarry that is worked occasionally.

Quarry west of Woodside Farm

	Ft.
1. Clay, greenish grey: seen for	3
2. Limestone, brown, flaggy, oolitic, crowded with blue-tinted oysters—in fragments and whole ...	4
3. Marl, yellowish brown, oolitic; fragments of oysters	½
4. Limestone, white, intensely hard, top part bored by annelids; no identifiable fossils observed: seen for	3

This section is difficult to interpret. It recalls that of Walker's Quarry (p. 48), but the clay and claystone layers of the latter are lacking here. The clay, 1, may be part of a lens in the Kemble Beds, but on the other hand beds 1-3 may be Wychwood Beds and 4 the top (' strong lime ') of the Kemble Beds.

The large disused Bradwell Quarry, two-fifths of a mile north-west of Woodside Farm, is mentioned by Plot (*see* p. 134). At the time of Woodward's visit, some of the fissile and obliquely-bedded masses of shelly and oolitic limestone were being worked for ' slates ' and ' planking ' (1894, p. 370).

Bradwell Quarry, Shilton

	Ft.	In.
Wychwood Beds		
1. Limestones, typical flaggy Forest Marble yielding large, thin flagstones with *Ostrea hebridica* Forbes, *Camptonectes sp.*, *Gervillia islipensis* Lycett, *Modiola sp.*, *Nucula waltoni* Morris and Lycett, *Nuculana sp.*, and rhynchonellids, with irregular layers of green clay and brown marl	3	0
2. Clay, green, locally shaly	3	0
3. Limestone, typical Forest Marble yielding flagstones	0	8
4. Clay, grey, with locally thin films of sandy limestone and at the base a thin 'Forest Marble' limestone full of *Ostrea hebridica* Forbes and crushed rhynchonellids joined on to the Kemble Beds	2	6
Kemble Beds		
5. Limestones: seen	3	0

At ' Norton Pits,' Brize Norton, quarrying of the Kemble Beds, for flagstones, etc., was actively carried on for many years. Only part of a large quarry is now worked occasionally for local purposes. In it can be made out Lower Cornbrash (with *Cererithyris intermedia* abundant in a basal layer), 4 ft. 6 in., resting on an eroded surface of clay (probably Wychwood Beds), 2 to 3 ft. thick, and this in turn on Kemble Beds, which have been exposed to a depth of 12 to 14 ft.

The Kemble Beds can still be seen in the face of an old quarry, north-west of Brize Norton, near the lane to Kilkenny Farm. Woodward (1894, p. 371) obtained the local names for the constituent beds: in descending order they are :—

		Ft.
Wychwood Beds.	Grey clay with ferruginous seams	2
Kemble Beds.	Slatt	12 to 14
	Strong lime	
	Planking vein	
	Soft bed	
	Freestone	
	Good weatherstone	
	Building-stone	
	Paving (ripple-marked slabs) ...	

The ' strong lime ' is of White Limestone facies. Woodward adds: " About 6 feet more of rock occurs below [the paving], but cannot be worked on account of water." The thinness of the Wychwood Beds (clay) will be at once noticed: no palaeontological evidence has been obtained for this allocation of the clay, but the limestones below are similar to those of the Kemble Beds of many other sections.

About three-quarters of a mile north-west of Caswell House, a small disused quarry shows, in descending sequence :—clay (1 ft.), a cream-coloured limestone largely composed of specimens of a rhynchonellid and shell-fragments (mostly of oysters) in a matrix of lithographic stone (1 ft.), and Kemble Beds (4 ft. seen).

The Cornbrash in the Ducklington Lane Quarry, half a mile due west of Witney Church, has been described by Douglas and Arkell (1928, p. 132) and the Wychwood Beds by Arkell (1931, pp. 589-592).

The following account is based on these descriptions.

Ducklington Lane Quarry, Witney

	Ft.
Lower Cornbrash	
Obovata Zone. 1. Limestone, hard, flaggy, poorly-fossiliferous ; *Ornithella obovata* (J. Sowerby), etc. : seen for	3
2. Rubble, loose, yellow, and marl ; *O. obovata* (abundant), *Clydoniceras sp.*, *Nucleolites clunicularis* (Smith), *Holectypus depressus* Leske, *Pygurus michelini* Cotteau, etc....	2
3. Limestone, hard, cream-coloured ; *O. obovata*, etc.	2
Intermedia Zone. 4. Limestone with pockets of fossils ; *Cererithyris intermedia* (J. Sowerby) abundant	1
Wychwood Beds	
4. *a* Clay, sandy, laminated, and marl, with thin hard bands (replaced towards the south-west by *b*) ...	2
b. Limestone, flaggy, false-bedded, blue-hearted, typical fissile Forest Marble, with ripple-marks, clay-galls and abundant *Placunopsis socialis* Morris and Lycett and small *Ostrea hebridica* Forbes on the surfaces of the slabs	3
c. Clay, grey, with occasional thin limestones ...	3
5. Bradford Fossil Bed. Rubble of mottled grey, cream and blue compact limestone and pasty marl, full of lignite, calcite, the coral *Cladophyllia babeana* Edwards and Haime and hundreds of small *Rhynchonella sp.*, as at Islip ; *Lima cardiiformis* (J. Sowerby), *Modiola imbricata* J. Sowerby, *Ostrea hebridica* Forbes, *Mytilus sublaevis* J. de C. Sowerby, *Digonella digona* (J. Sowerby), *Cidaris bradfordensis* Wright :	1 ft. 6 in. to 2
Kemble Beds	
6. Limestone, massive, false-bedded, bluish-grey, coarsely oolitic, with large logs of lignite several feet long in the upper part : formerly seen to ...	8

Noteworthy features of this section are :— (1) the very fossiliferous development of the Bradford Fossil Bed, its fossils including *Digonella digona*, and (2) the replacement locally of a considerable part of the overlying clay by limestone.

Large quarries to the north-east of Witney Cemetery are over-grown. According to Horton : “ This [Wychwood Beds] clay is divided about the centre by a thin bed of slatey sandstone, which, although not equal to the Stonesfield Slate for the purpose, is capable of being worked by the hammer into a rough kind of roofing tile.” Horton recorded *Digonella digona* from here, and Edward Lhuyd, (1699, No. 873, Table 10) figured a specimen of *D. digona* from Witney, under the name *Sacculus minor vulgaris* : the type-specimen is in the Old Ashmolean Museum, Oxford.

The section in the large Crawley Road Quarry, just over a mile north by west of Witney Church, has been described by Arkell (1931, pp. 590-592), but is now greatly enlarged and beds 7, 8 and 9 in the following record are exposed.

Crawley Road Quarry, Witney

		Ft.	In.
Wychwood Beds			
1.	Clay, bluish grey, with half a dozen thin layers of locally fissile limestone; occasional *Ostrea hebridica* Forbes	6	0
2.	Clay, similar: thickens from west to east, from 1 ft. to	4	0
3.	BRADFORD FOSSIL BED. Limestone, cream-coloured, rubbly, locally hard-centred; crowded with *Lima cardiiformis* (J. Sowerby) and *Ostrea hebridica* Forbes, and, according to Arkell, " all the fossils in Ducklington Lane Quarry, especially the Rhynchonellids, coral, and fragments of Cidarid." In one place in the western side of the quarry this bed expands to 4 ft. 9 in., cuts out the two beds below, and rests directly on the Kemble Beds; while in the eastern part of the quarry there was a large surface of the Kemble Beds (above the clay lens) exposed on which crowds of lamellibranchs, rhynchonellids, and *Terebellaria ramosissima* Lamouroux of the Bradford Clay fauna were seen	2	6
4.	Clay, green, sandy	1	0
5.	Marl, tough, laminated	1	3
Kemble Beds			
6.	Limestones, massive, false-bedded, coarsely oolitic, with partings of shale or limestone laminae. A lens of blue shaly clay with oysters, at the top, thickens rapidly eastward to 4 ft. and then thins out. The lower part of the limestone above the clay has inclusions of White Limestone	10	0
White Limestone			
7.	Marl, yellowish-green, with a 3-in. layer of yellowish limestone with *Natica intermedia* Morris and Lycett and *Ostrea hebridica* Forbes abundant, which expands into boulder-like masses of white limestone (often enclosing large pieces of lignite) at the expense occasionally of the bottom part of the Kemble Beds above and frequently of that of the clay (9) below: 3 in. to	2	0
8.	*Gervillia waltoni* Bed. Limestone, greenish yellow, locally hard, argillaceous; crowded with *Gervillia waltoni* Lycett, *Nucula waltoni* Morris and Lycett, and *Placunopsis socialis* Morris and Lycett; also *Natica intermedia* Morris and Lycett, *Nerita minuta* J. de. C. Sowerby, and *Ostrea hebridica* Forbes: 0 to	0	10
9.	Clay, blue, with occasional boulder-like masses of limestone; *Ostrea hebridica* Forbes and *Placunopsis socialis* Morris and Lycett common: 0 to	0	10
10	Limestone, white, blue-hearted; fragments of lignite locally abundant	2	8

		Ft.	In.
11.	Witney Coral Bed. Limestone, very similar to (10), locally lithographic and intensely hard and splintery; crowded with *Epithyris oxonica* vars. *kemblensis*, *transversa* and *alta* Arkell, *Stiphrothyris capillata* Arkell, *Lima cardiiformis* (J. Sowerby), *Convexastraea waltoni* Edwards and Haime and *Thamnastraea lyelli* Edwards and Haime; also *Trochotoma obtusa* Morris and Lycett and *Navicula* (*Eonavicula*) *minuta* (J. de C. Sowerby) ...	2	4
12.	Marl, grey, brown and green in irregular seams, the lower part locally hardened into an impersistent clay-limestone as at Gibraltar, full of fossils difficult to recognise; *Protocardia subtrigona* (Morris and Lycett) ...	1	8
13.	Clay, black	0	8
14.	Middle *Epithyris* Bed. Marl, brown, passing down into brown rottenstone, full of large *Ostrea hebridica* Forbes and crushed *Epithyris oxonica* Arkell	0	8
15.	Limestone, hard, brown...	1	6
16.	Clay: 2 in. to	0	3
17.	Limestone, green argillaceous	0	10
18.	Limestones, cream-coloured (badly exposed): up to	2	6

The fossils of the *Gervillia waltoni* Bed (8), clearly correlate with part at least of bed of the old Cement Works Quarry, Kirtlington (p. 70), and along with beds 7 and 9 in the Witney quarry, in the western part attenuate to form a mere parting of marl and stone as in Viner's Quarry, Kirtlington (p 69). The black clay of Crawley Road Quarry, Witney, is identical in appearance with that part of clay bed 6, which overlies the Middle *Epithyris* Bed of Kirtlington. It may be provisionally taken, therefore, that beds 7 to 13 at Witney are on the horizon of bed 6 of Kirtlington.

On the south side of the Witney-Burford road opposite the Minster Lovell bridge is the quarry to which Hull (1859, p. 20) referred as showing the White Limestone succeeded by the Forest Marble. The beds mentioned by Hull as Forest Marble, and, for reasons given on p. 36, still represented as such on the map, are Kemble Beds. The section given below has been described recently by Arkell (1931, p. 608).

Minster Lovell War Memorial Quarry

		Ft.	In.
Kemble Beds			
1.	*a*. Flags, steeply false-bedded, like Forest Marble	4	6
	b. Marls, laminated buff and rusty, even-bedded to slightly wedge-bedded, with lenses of thin oolitic limestone; at the base a 2-in. band of sandstone concretions ...	2	0
	c. Limestone, hard, false-bedded, weathering flaggy	1	0
2.	Upper *Epithyris* Bed. Marl, chalky, cream-coloured; crowded with *E. oxonica* Arkell: 6 in. to	0	8
White Limestone			
3.	*Aphanoptyxis bladonensis* Bed. Limestone, white, intensely hard; crowded with *A. bladonensis* Arkell and thin lamellibranchs seen in section: also small branching corals	2	9

	Ft.	In.
4. Limestone, white, oolitic, in thick beds; unfossiliferous	6	0
5. *Ptygmatis* rock. Limestone, white; crowded with *Ptygmatis* (*Bactroptyxis*) *bacillus* (d'Orbigny)	1	0
6. Marl, white, chalky: seen for	0	6

Arkell regarded bed 2 as being correlative with the Upper *Epithyris* Bed and since it is post-*bladonensis* in date it may be tentatively regarded as such. Arkell saw the *Nerinea eudesii* Beds exposed during road-widening operations at a lower level than the bottom of the quarry a little to the east and almost opposite the turning to Minster Lovell village, but it may be remarked that in a quarry south of Combe (p. 60) *Ptygmatis bacillus* occurs, apparently, in the bottom stratum of the *Nerinea eudesii* Beds.

The Kemble Beds in the Minster Lovell quarry belong to the lower part of the subdivision: a boring at White Hall (formerly Starveall Farm), about a mile to the south-west, revealed a thickness of 19 ft. of these beds.

White Hall Boring, Minster Lovell

		Thickness Ft.	Depth Ft.
Wychwood Beds	Top stone	4	4
	Blue clay	23	27
Kemble Beds	White lime [limestone] ...	19	46
White Limestone	Blue clay	1	47
	White stone	8	55
	Blue clay	2	57
	White stone	13	70
	Blue clay	2	72
	White stone	1½	73½

The above particulars, except the classification, were supplied by Mr. H. G. Godwin, of Quenington, by whose firm the boring was made in 1933.

The 23 ft. of clay is clearly Wychwood Beds and doubtless contains thin beds of limestone, for such were seen in excavations made in connection with the Witney Urban District Council's water undertaking, etc:—

	Ft.
Pipe-trench near White Hall Reservoir:	
1. Clay: seen for	8
Pipe-trench approximately opposite to the entrance to White Hall:	
1. Clay, bluish-grey; occasional small *Exogyra sp.*: seen for	3
2. Limestone, typical Forest Marble; rhynchonellids	1½
3. Clay, as above: seen for	1
In bank alongside the Burford road to the west:	
2. Limestone, as above; *Gervillia islipensis* Lycett	traces
3. Clay, as above	5
4. Limestone, typical, false-bedded, flaggy Forest Marble with abundant fossils; *Camptonectes laminatus* (J. Sowerby), *Ostrea hebridica* Forbes: seen	1½
Trench for telephone cable:	
5. Clay: not well displayed: ? about	6
Kemble Beds	
6. The top bed crops out below 5.	

Walker's Quarry half a mile west of Asthall tumulus, and 250 yds. south of the Burford road shows:—

Walker's Quarry, Asthall

	Ft.	In.
Kemble Beds		
1. Rubble of white limestone, sandy, and white marl, disturbed, passing down into ...	3	4
2. Limestone, brownish, sandy, with brown plant remains, with which is associated locally brown, sandy ‘ marl ’ : about ...	3	0
3. Limestone, very similar to 2, but fissile and weathering to a marl : 0 to	0	8
4. Limestone, bluish grey, oolitic, largely composed of fragments of oysters in a matrix of calcite ; bits of black lignite. The bottom 14 in., is packed with large specimens of *Ostrea hebridica* Forbes	4	0
5. Marl, brown, oolitic, enclosing locally ‘ lumps ’ of limestone ; crowded with crushed oysters	0	4
6. Limestone, hard, white, rather ‘ lumpy ’ at the top with locally an irregular iron-stained surface ; ? bored by annelids ; occasional oysters	1	0
White Limestone		
7. Clay, brown, oolitic, marly, but locally greenish	0	2
8. Claystone, white	0	5
9. Limestone, hard, sublithographic, white and pinkish brown, surface waterworn, ferruginous and pitted. Locally crowded with lamellibranchs ; *Aphanoptyxis bladonensis* Arkell, (one specimen noted), *Fibula variata* Lycett	1	0
10. Limestone, white	1	4
11. Limestone, very similar to 10 but more oolitic : seen for	3	0

This section is useful because it demonstrates that Kemble Beds of similar lithic facies to those in the south-western part of the district, as at Brize Norton, etc., are present here. They have immediately below them certain readily-recognisable clay and claystone layers on the horizon of bed 7 of the Crawley Road Quarry (p. 45). Identical layers occur in the Eton College Quarry (*see below*), north of the Burford road, half a mile east of Asthall tumulus. Here, however, the Kemble Beds above the layers present some differences.

Eton College Quarry, Asthall

	Ft.	In.
Kemble Beds		
1. *a.* Limestone, fine-grained, creamy white to yellowish, oolitic, false-bedded and unfossiliferous : seen for	10	0
b. Limestone, white, lithographic, the lowest 3 in. cream and oolitic, like *a*	1	4
(*Marked plane of erosion*)		
White Limestone		
2. Clay, green : 0 to	0	2
3. Claystone, compact, greyish white with some small indeterminate fossils : 0 to	0	6

		Ft.	In.
4.	*Aphanoptyxis bladonensis* Bed. Limestone, hard, white to grey, lithographic; a mass of *A. bladonensis* Arkell at all stages of growth, also *Gervillia waltoni* Lycett, *Trigonia sp.* and other fossils difficult to identify: 2 ft. to	4	8
5.	Clay, green, with white pellets, as at Greenhill (p. 68), with brown very sandy marl above and below full of (?) leaf-markings and fragile shells, especially *Gervillia waltoni* Lycett and a small lamellibranch shaped like a *Tancredia* but too badly preserved for identification: 1 ft. 6 in. to	2	0
6.	Claystone, tough, grey, speckled, full of fossils impossible of identification; *Aphanoptyxis*: 6 in. to	0	8
7.	?Middle *Epithyris* Bed. Marl parting; occasional loose valves of *Epithyris*: 1 in. to	0	3
8, 9.	*Aphanoptyxis ardleyensis* Beds. Limestone in two courses, hard, massive, white, somewhat suggestive of Dagham Stone; abundant *A. ardleyensis* Arkell and *Lucina* ...	3	9
10.	Marl, pale, laminated, the upper half indurated: 6 in. to	0	10
11.	Limestone, solid beds of whitish; *Trigonia pullus* J. de C. Sowerby	2	8
12.	Marl parting	0	3
13.	Limestone, brownish, sandy; casts of *Pholadomya, Ceratomya* and *Homomya*	3	0
14.	Limestone, white, rubbly, in two courses ...	2	0
	Present base of quarry.		
15.	Clay, grey, marly	2	9
16.	Fossil Bed; rhynchonellids, terebratulids, *Clypeus, Acrosalenia*, '*Natica*' and lamellibranchs	0	3
17.	Limestone, pinkish, oolitic: formerly seen to	3	3

As Arkell, who has described this section in detail (1931, pp. 606-609), remarks, " The most striking feature is the expansion of the maximum of *Aphanoptyxis bladonensis* through nearly 5 feet of hard white limestone of Cream Cheese facies." He records the discovery by Mr. C. C. Gaddum of " an ammonite identifiable with *Tulites subcontractus*, which is now in the Oxford University Museum." It was not found *in situ*, but, judging by the matrix, it probably came from bed 17 above. Arkell also says: " A puzzling feature of this quarry at first is the absence of the ubiquitous *Nerinea eudesii* Beds, but it is probable that the westerly thickening of the Great Oolite has separated them farther from the *A. ardleyensis* bed, and that they lie below. This supposition is borne out by their reappearance 1½ miles west-north-west, in the bottom of a small quarry south of the road at Sturt Farm, and again the same distance east-north-east, south of the main road at Minster Lovell, where they were recently exposed during road-widening operations in the dip east of the war memorial (*see* p. 47). It may be, however, that beds 11-14 are in part or whole on the horizon of the *Nerinea eudesii* Beds.

Kemble Beds, similar to those in the Eton College Quarry, are to be seen, separated by the clay and claystone layers from White Limestone, in a quarry on the south side of the Burford road a quarter of a mile north-west of Sturt Farm, and were formerly worked between Barns Lane (in front of the houses at Burford called ' The Leaze ') and the road that descends the steep hill through the town from the Cotswold Gateway Hotel. ' The Leaze ' are built of rock that was quarried here.

In a quarry, now almost entirely overgrown, at the meeting of the Oxford and Shilton roads above Burford, there is a small outcrop of White Limestone, marly at the base, which would appear to be correlative with bed 9 of Walker’s Quarry (p. 48).

In a quarry now filled with rubbish, about half a mile south-west of Burford Church, near the Cotswold Gateway Hotel, Woodward (1894, pp. 304, 305) observed :—

Quarry near the Cotswold Gateway Hotel, Burford

	Ft.	In.
“ Brown clayey and stony soil	1	0
Forest Marble (= Bradford Clay?)		
Grey, greenish grey and brown clay, with thin layers of gritty and shelly limestone : *Avicula, Ostrea acuminata, O. lingulata, O. gregaria, O. sowerbyi, Rhynchonella, Serpula*, etc.	3	6
Ferruginous marly and racy bed, with interrupted masses of hard brown shelly oolite at base ...	1	0
Great Oolite (Upper Division)		
Hard brown oolites	2	6
White fine-grained oolite	1	7
Brown fine-grained and rather earthy oolites.”		

The deposit Woodward queries as “ = Bradford Clay ” is, most likely, that clay and the ‘ oolites ’ classified by him as ‘ Great Oolite (Upper Division)’, by description and position, Kemble Beds.

In an open drain on the Cheltenham road a little to the west of the Cotswold Gateway Hotel are displayed :—

Section west of the Cotswold Gateway Hotel, Burford

	Ft.
Clay, green and brown : seen for	2
Limestone weathering into small tabular pieces : about	2
Limestone, very similar and full of oysters, containing—at the western end—rolled pieces of white limestone	1
Fossil Bed. Marl and rubble, cream-coloured, with abundant *Epithyris oxonica* Arkell and *Ostrea hebridica* Forbes passing westwards into relatively barren greenish grey marl : seen for	2

It is difficult to come to a conclusion as to the classification of these beds and neighbouring sections afford little assistance. The Fossil Bed with its abundant epithyrids suggests White Limestone ; the superincumbent limestones are almost certainly Kemble Beds, and the clay may belong to the same subdivison.

In Burton Copse, on the south side of the road half a mile west of Bury Barns, a fine-grained yellow sand has been dug. The following is the result of an examination of the detrital minerals made by Mr. I. S. Double of Liverpool University :—

Zircons.—One little sharp-edged prism, .06 mm. : some purple and zoned	Very common
Garnet.—Colourless, etched, .08 mm.	Not common
Rutile.—Reddish, also yellow ; geniculate twins ; some aggregates	Fair number
Muscovite.—.2 mm....	Not common
Chlorite.—Apparently from biotite. Thin green plates	Several
Tourmaline.—Nice prisms and broken grains, smoky grey and greenish	Fair number
Kyanite.—	Scarce
Hornblende.—Pale coloured. Extinction 10° to cleavage	Scarce

As regards stratigraphical position, this sand is provisionally assigned to the Wychwood Beds (*see also* p. 52).

A well was sunk in 1933 half a mile south-west of Hailey Church, on the south side of Foxburrow Lane. The information was obtained from the well-sinker and from an examination of the spoil.

Foxburrow Lane Well, Hailey

	Ft.
Cornbrash: Limestone, rubbly	12
Wychwood Beds: Clay, blue, stoneless except for a layer of limestone with numerous small fossils such as are seen locally on the horizon of the Bradford Fossil Bed...	14
Kemble Beds: Limestone with fissures	

North of Foxburrow Lane, at two-fifths of a mile south-west of Hailey Church, the clay bed proved by the well was formerly dug for use in the fulling-stocks at the blanket mills of Witney.

A little over a third of a mile south-east by south of Asthall Leigh Church is an interesting section:

Saddlegate Quarry, Asthall Leigh

	Ft.	In.
Heavy clay soil with drift pebbles, passing down into		
Wychwood Beds		
Clay	2	0
Limestone, brown, sparsely oolitic, shelly; rhynchonellids (some approaching *Rhactorhynchia obsoleta* (Davidson)), *Acrosalenia sp.*, *Ostrea hebridica* Forbes, with numerous fragments of lignite and clay-galls	0	3
Clay	0	3
Limestone, very similar to that above	0	6
Kemble Beds		
Limestone, bluish grey, largely composed of shell debris, bedded, but individual layers are false-bedded, weathering into small tabular pieces, and gravelly in the bottom part	2	6
Limestone, grey, oolitic, weathering white and lime-washed	5	0

A short distance within Wychwood Forest, to the north of Gospel Oak is the quarry described below.

Dogslade Quarry, Wychwood Forest

	Ft.	In.
Wychwood Beds		
1. Limestone, false-bedded, flaggy, bluish, with white ooliths and full of minutely-ground oyster-fragments. The rock is disturbed and occurs in pockets: up to	2	0
2. Clay, blackish: up to	3	0
Kemble Beds		
3. Marl, brown, with crushed epithyrids in the basal part	0	9
4. Upper *Epithyris* Bed. Limestone, white, wedge-bedded, packed with fossils, attenuating and becoming marly, but, as it attenuates, bedded hard splintery white limestone comes in on top; *Epithyris oxonica* var. *kemblensis* Arkell and *Convexastraea waltoni* Edwards and Haime very abundant.		

Upper *Epithyris* Bed—*continued*	Ft.	In.
Stiphrothyris capillata Arkell (common), one specimen each of *Aphanoptyxis bladonensis* Arkell and *Trochotoma obtusa* Morris and Lycett, *Lima cardiiformis* (J. Sowerby), *Modiola imbricata* J. Sowerby, *Trigonia sp.*; 6 in. to	3	6
Limestone, flaggy, bluish with white ooliths and looking as if composed of ground up oyster shells	1	4
6. Marl, yellow, rubbly: 3 to	0	6
7. Limestone, similar to (5), massive but false, bedded: seen for	4	0

This section is important because it shows a white limestone facies at the top of the Kemble Beds overlying the unmistakable bluish limestones of the subdivision. The part rich in corals and brachiopods does not occur as a regular horizontal bed, and in places unfossiliferous white limestone occurs immediately below the clay.

Hens Grove Quarry, described by Woodward (1894, p. 308), is half a mile east of Pains Farm, between Hens Grove and the road.

Hens Grove Quarry, Swinbrook

	Ft.	In.
Kemble Beds		
1. Limestone, flaggy, false-bedded, with irregular and impersistent deposits of brown, locally clayey and stony, marl: seen for	5	9
? Kemble Beds (White Limestone facies)		
2. Limestone, very hard, white, oolitic, splintery—the ' White Oolite: very shelly bed with Gastropods ' of Woodward	1	6
3. Woodward recorded below: " Hard white more or less oolitic rock, the grains here and there more prominent and scattered in finer oolitic base	3	6

Woodward observed ' nodular ' (?pebbly) stones in the base of his Forest Marble—bed 1 above. Arkell (1931, p. 594) expressed the opinion that Woodward's Forest Marble is " more likely to be pre-Bradfordian, equivalent in age to the Kemble Beds," and the information obtained from Dogslade Quarry suggests that the white limestone below is a White Limestone facies of the Kemble Beds.

The high ground to the south of Hens Grove is capped with a sandy deposit that gives rise to a veritable heath. In this tract there are extensive old workings near Holywell Barn, south-west of Stockey Copse, in which yellow sand is seen in old waste heaps.

It is clear that the sand occurs in association with calcareous sandstones, fragments of which can be found lying about and used in the construction of the fields walls. The yellow sand recalls the Burton-Copse sands (p. 50) and the Hinton Sands of the type-locality, Charterhouse Hinton between Frome and Bradford on Avon. The following is the result of an examination of the detrital minerals in a sample of the sand from near Holywell Barn made by Mr. I. S. Double of Liverpool University :—

Zircon.—Colourless and clear, few zoned and purple forms	Common
Sillimanite.—	Not common
Tourmaline.—Blue, green and smoky	Abundant
Staurolite.—Yellow and pleochroic	Not common
Kyanite.—Cleavage flakes	Not Common
Rutile.—Red and yellow	Common

Garnet.—Clear, colourless and etched	Common
Brookite.—Yellow and striated	Very rare
Apatite.—	Very rare

On the south side of Holywell Barn a weak spring (emerging in Wychwood Beds ground) feeds a small ' dip ' that was once a ' holy well ' : it is at the head of a valley that runs southward to the River Windrush.

Kingstanding Quarry lies between Kingstanding Farm and High Lodge.

Kingstanding Quarry, Wychwood

	Ft.	In.
Soil, clayey, with drift pebbles, passing down into	—	—
Wychwood Beds		
Clay, tough, brown, bluish and greenish : about...	1	0
Kemble Beds		
1. Marl, yellowish, with abundant small oysters	0	8
2. Limestone, oolitic, irregularly flaggy, largely composed of debris of echinoids : weathers into curious shapes	1	6
3. Marl, yellowish, stony ; aboundant oysters ...	0	6
4. Limestone, bluish grey, oolitic, false-bedded ...	2	0
5. Marl, as above	0	6
6. Limestone, white to creamy white, rubbly ; lamellibranchs (indeterminate) : seen for ...	1	6

It may be noticed that the bottom-bed is of incipient White Limestone facies and that bed 2, parts of which weather into curious shapes, is largely composed of fragments of sea-urchins. Hull identified his White Limestone in some quarries below High Lodge and along the road between Ranger's Lodge and Leafield (1859, p. 20). In some cases Hull may have regarded limestone of White Limestone facies in the Kemble Beds as White Limestone.

West of Slatepits Copse the lowest three beds as seen in the Kingstanding Quarry are exposed in an old working. The lowest bed, seen for 2 ft., is very hard, white limestone (of White Limestone facies) and contains some large specimens of *Aphanoptyxis bladonensis* Arkell and an occasional *Gervillia waltoni* Lycett. Further north, tough Wychwood Beds clay was exposed to a depth of at least 4 ft.

Close to the road east of Priest Grove typical Kemble Beds as seen in :—

Woeful Green Quarry, Ascot under Wychwood

	Ft.
Kemble Beds	
2–4. Limestone, weathering into small tabular pieces and part, in places, into curious shapes ; locally at the base, gravelly : up to	3
5, b. Fragments of white limestone set at all angles in white marl : up to	2
7. Limestone, more massive, but false-bedded, cream-coloured, oolitic, becoming browner and harder lower down	10
8. Limestone, grey, locally bluish centred, with white ooliths and scattered oysters. Large pieces can be drawn : seen for	3

Bed 5, b is of White Limestone facies and bed 2-4 clearly correlative with one or more of the limestone beds above that of White Limestone facies in the Kingstanding Quarry.

Two quarries, near Shipton Barrow, both on the north side of the road, one, north-west, the other west-by-north of Down's Farm, display much the same section. The following description is of the first quarry.

Quarry near Shipton Barrow

	Ft.	In.
Soil brown, clayey	1	0
Kemble Beds		
2. Limestone, buff, sandy (almost a calcareous sandstone), weathering into curious shapes; tracks, crowds of pentacrinoid joints ...	0	10
3. Marl and marly clay, yellowish brown, stony	0	9
4. Limestone, pale grey, coarsely oolitic but the bottom part very sandy; full of echinoid remains	1	2
5. Marl, yellowish brown, stony: seen for ...	0	6

The top bed appears to be contemporaneous with the limestones above that of White Limestone facies at Kingstanding and Woeful Green quarries. In the plantation to the south of the second quarry was formerly another called 'Plank Quarry'—a name that suggests that the main part of the Kemble Beds, which yields 'planks' or flagstones, used to be worked here.

Close to the road to Shipton under Wychwood, a little to the north of Fulbrook Gap is the 'Capps Lodge Quarry' of Tomes (1883, p. 170).

Capps Lodge Quarry, Fulbrook

	Ft.	In.
Clayey soil with drift pebbles: up to	1	3
Wychwood Beds		
1. Bradford Clay. Clay weathering pale greenish grey with abundant *Ostrea hebridica* Forbes, also *Cidaris bradfordensis* Wright (plates and radioles not uncommon), *Lopha bathiensis* (Rollier) (*nom.nov.=Ostrea gregaria* Morris and Lycett *non* J. Sowerby), and *Serpula* with a tough blue clay with *Placunopsis* at the base: up to	1	0
Kemble Beds		
2. Irregular and impersistent layers of blue-hearted, broken-shell limestones of Forest Marble facies, and tough clay—the upper part bluish grey, the lower part black ...	2	4
3. Clay, black, brown-streaked	1	0
4. Marl, buff, oolitic	0	9
5. Limestone, buff, finely oolitic, bedded, with an occasional impersistent layer of shale passing laterally into a bluish limestone with oysters and angular and rolled pieces of white limestone (some bored by *Lithophaga*) locally welded to the surface of the bed below	1	10
? Kemble Beds (White Limestone facies)		
6. Limestone, brownish white, splintery: seen, 1935, 1 ft.; according to Woodward, 'white imperfectly oolitic limestones' ...	2	8
7. Coral Bed	1	3
8. Limestone: seen by Tomes	5	0

The clay at the top is probably representative of Bradford Clay and as this deposit constitutes the base of the Wychwood Beds, beds 2 and 3 are grouped with the Kemble Beds. The white limestone fragments in bed 5 appear to be connected with the erosion of which there is evidence at this horizon in a number of sections (pp. 52, 53). Tomes placed the limit of the Forest Marble in approximately the same position as the base of bed 3 in the above record, but Arkell (1931, p. 594) expressed the opinion that the beds down to and including the pebble-bed (5) are more likely to be Kemble Beds.

The sections from Dogslade Quarry onwards point to the white limestone, of which 1 ft. is seen in the Capps Lodge Quarry, being a White Limestone facies of the Kemble Beds. At 2 ft. 8 in. below the top of this, but not now exposed, is the rich coral bed described by Tomes as " A white and yellow mudstone, sometimes very soft, but held together by shells and corals," from which he recorded:— *Isastraea limitata* Lamouroux, *I. explanulata* Edwards and Haime, *Latimoeandra lotharinga* Fromentel, *Cladophyllia babeana* Edwards and Haime, *Convexastraea waltoni* Edwards and Haime, *Stylina conifera* Edwards and Haime, *Thamnastraea microphylla* Tomes (type locality) and *Microsalena excelsa* Edwards and Haime, while Arkell and the writer recorded, from masses that are used as ' toppers ' for the wall between the road and the quarry abundant *Epithyris oxonica* Arkell and oysters; also *Trochotoma obtusa* Morris and Lycett, *Camptonectes obscura* (J. de C. Sowerby), *Modiola imbricata* J. Sowerby, *Mytilus sublaevis* J. de C. Sowerby, etc. Tomes remarked: " The general facies of the corals . . . much resembles that of the Fairford corals," and the limestones below the Coral Bed have " the character of true Great Oolite."

Having described the Kemble and Wychwood Beds as seen in quarries in the western part of the district, it is convenient to consider the area to the east, commencing with the neighbourhood of Ramsden.

Kemble Beds are well displayed in a quarry close to the Charlbury road east-by-south of Brize's Lodge.

Brize's Lodge Quarry, Ramsden

	Ft.	In.
Heavy clay soil studded with drift pebbles, in places going down fissures in the Kemble Beds limestones: up to	2	0
Wychwood Beds		
Clay, tough, greenish	1	6
Limestone; small oysters and *Placunopsis* fairly common	0	3
Clay, tough, greenish	1	3
Limestone of Forest Marble facies in thin layers with clay partings, horizontal and continuous	1	0
Kemble Beds		
Limestone, hard, grey, oolitic, locally largely made up of shell debris, in the main massive bedded, but the individual massive beds are conspicuously false-bedded. Locally the top part weathers into small tabular pieces; seen for	20	0

Woodward (1894, p. 372) noted a very similar section near Whiteoak Green, but the quarries are now almost obliterated.

About a fifth of a mile south-south-west of The Hayes, Wilcote, is a quarry ' in work '.

Quarry near The Hayes, Wilcote

	Ft.	In.
Kemble Beds		
Limestone, false-bedded, weathering into small tabular pieces	6	0
Clay and shaly limestone, impersistent: up to	0	4
Limestone, as in Brize's Lodge Quarry, but with occasional clay-galls and lignite as in the Hanborough Station Quarry: seen for	8	0

In The Hayes (Ramsden) Boring (Pringle, 1926, p. 5), a thickness of 25 ft. is assigned to the Forest Marble; *i.e.* the Wychwood and Kemble Beds in this district.

According to the same author (1926, p. 18): “ In the Wilcote Valley . . . this formation [the Forest Marble] rests with marked unconformity on the Great Oolite limestones as is shown by a section in the old quarry by the road about a quarter of a mile west-south-west of Wilcote.” The quarry is now overgrown and the writer has been unable to see the unconformity referred to, but greenish clay—approximately the base of the Wychwood Beds—can be made out overlying Kemble Beds limestones.

About half a mile north-north-east of Holly Copse Farm, west of East End, North Leigh, an important section has been displayed in a quarry opened by Mr. M. Breakspear, Jun. The lime made from these Kemble Beds is said to be preferred by many bricklayers to that made from the White Limestone as it is more ‘ fatty ’.

New East End Quarry, North Leigh

	Ft.	In.
Soil and brown clay with drift pebbles	—	—
Lower Cornbrash		
1. Limestone, irregularly flaggy, disturbed; *Cererithyris intermedia* (J. Sowerby). *Pleuromya uniformis* (Morris and Lycett)	1	0
Wychwood Beds		
2. Clay, bluish grey, with thin limy layers and ‘ pellets ’, resting on a ferruginous and hardened surface of the limestone below ...	3	0
Kemble Beds		
3. Limestone, greyish, locally bluish grey oolitic, shelly (mostly oysters), massively bedded but the individual layers are false-bedded. Locally there are deposits of clay with thin layers of limestone which participate in the false-bedding of the limestone. At positions varying from 5 ft. from the top to 3 ft. from the bottom occurs, intermittently developed, the Upper *Epithyris* Bed precisely similar to its equivalent in Dogslade Quarry (p. 51), packed with coral (*Convexastraea waltoni* Edwards and Haime and *Lima cardiiformis* (J. Sowerby)), and, less abundantly, *Epithyris oxonica* Arkell	12	0
White Limestone		
4. Clay, tough, greenish grey to black, with much lignite at the top	1	2

No palaeontological evidence has been obtained in support of allocating the clay concerned to the Wychwood Beds; the classification must therefore be regarded as tentative.

Nearby is the old Whitehill Wood Quarry which has been described by Woodward (1894, pp. 318, 319) and Pringle (1926, p. 18) and referred to by Arkell (1931, p. 611). At the top, the bottom part of the Kemble Beds is seen and then, in descending sequence the green clay (regarded by Woodward and Pringle as the basement bed of the Forest Marble), white marl with clay layers and lumps of limestone, a hard white limestone with lamellibranchs (*Eocallista islipensis* (Lycett), *Gervillia waltoni* Lycett, *Pinna odlingi* Arkell, etc.) recalling the fossiliferous part of bed 9 of Walker’s Quarry (p. 48), and soft marly limestone. Lower beds are now indifferently exposed.

The importance of the new East End Quarry is that it shows that typical Kemble Beds are present here, that the Coral or Upper *Epithyris* Bed, identical with that at Dogslade Quarry, is developed at various positions in the Kemble Beds (at Dogslade Quarry at and near the top, here towards the median part), and that the clay with marl which crops out near the top of the old Whitehill Wood Quarry is the immediate sub-Kemble Beds clay.

The old East End Quarry, not now ' in work ', presents a very similar section to the new one (*see* Woodward 1894, p. 318; Pringle 1926, p. 19).

The quarry north of the Swan Inn, Long Hanborough, displays the most complete section of the Cornbrash in the district west of the River Cherwell, and the underlying Wychwood Beds resting on the Kemble Beds. The section has been dealt with by Pringle (1926, p. 19), and by Arkell (1931, p. 558), both singly and in conjunction with Douglas (1928, pp. 129, 130).

Swan Inn Quarry, Long Hanborough

	Ft.	In.
Pleistocene Deposit		
River gravel of the Hanborough Terrace (*see* p.)	6	0
Kellaways Beds		
Clay, blue : 8 in. to	2	0
Cornbrash (*see* p. 76)	8	6
Wychwood Beds		
Clay, white ; *Placunopsis* abundant	0	9
Limestone, massive ; *Actaeonina luidii* Morris, *Amberleya sp.*, *Lithophaga sp.*, *Modiola sp.*, *Camptonectes rigidus* (J. Sowerby) and Rhynchonellid	1	0
Clay, shaly	1	0
Rottenstone ; *Placunopsis sp.*, *Camptonectes rigidus* (J. Sowerby)	0	3
Clay, blue	0	5
Kemble Beds		
Massive oolite ; *Rhynchonella spp.*: seen for ...	5	6

The Kemble Beds were first identified here by Arkell. Concerning the beds between them and the Cornbrash, he remarks that they are " like Forest Marble," but their age " cannot be accurately determined. One of the beds is full of *Cylindrites luidii*, like a bed in a similar position near Shields Farm, north of Alvescott, some 10 miles to the south-west. The inclination is to call the top beds Wychwood Beds, but as the Bradford Clay is still absent there is nothing to prove that all are not Kemble Beds." In the opinion of the present writer the appearance of the beds and the occurrence of the gastropod link them with the Bradford Clay of the quarry near Shield Farm (p. 42).

In the steep side of the valley of the Windrush below the Swan Inn Quarry another—the Layshillwood Quarry—was opened in 1934, in which almost the whole of the White Limestone subdivision is exposed. Locally, at the top of the main section are seen the basal flaggy limestones of the Kemble Beds (they are more extensively exposed and accessible in an adjoining old working to the east), while near the quarry entrance a good spring, which is probably thrown out by the Hampen Marly Beds, discharges into the river. The thickness of the White Limestone beds exposed is 52 ft. The Coral Bed (bed 18) at the base is at or near the bottom of the White Limestone so that this may be regarded as the approximate thickness of the subdivision here. The Hampen Marly Beds are exposed in a quarry near Westfield Farm (p. 36); in the neighbouring railway-cutting Hull (1859, p. 17) saw a coral-bed doubtless correlative with this one in the Layshillwood Quarry.

Layshillwood Quarry, Long Hanborough

	Ft.	In.
Kemble Beds		
Limestone, flaggy, strongly oolitic : seen for ...	2	0
White Limestone		
1. Clay, tough, dark	0	6
Clay, white, marly, with dark layers : 6 in. to	0	

		Ft.	In.
2.	Marl, white and yellow with lumps of white marly limestone and some layers of very hard false-bedded limestone especially at the top	4	0
3.	Limestone, prominent bed, hard, strongly oolitic, false-bedded: up to	2	0
4.	Limestones, conspicuously soft, white, and marly, with much white lime and four horizontal bands of brownish marl ...	5	0
5.	Marl, brown, overlying tough dark green clay	0	6
6.	Limestone, hard massive bed, beautifully oolitic, with a pronounced pinkish tinge; very homogeneous throughout, has to be blasted: up to	3	6
7.	Marl, greenish grey, with brown clay layers and at the top flattened concretions of very ferruginous clay. Locally replaced by limestone	0	10
8.	Limestone, top part of bed 'knobby' and ferruginous, hard, pinkish grey, strongly oolitic; *Pinna sp.*, *Trigonia sp.*, and occasional ?corals	2	2
9.	*Aphanoptyxis ardleyensis* Bed. Limestone, hard, white, oolitic, locally sandy to the touch and locally marly, breaking up into three or four layers; many *Aphanoptyxis* (?small *ardleyensis* Arkell) in layers and 'nests' and sections of larger *Fibulae* or *Pseudomelaniae*	2	9
10.	Series of four to six or more softer limestone beds with marl partings, the limestones becoming locally very marly and soft ...	6	6
11.	*Nerinea eudesii*-Beds. Massive beds. *a.* Limestone very similar to 14*c*, top part of the bed 'knobby' and ferruginous: 1 ft. *b.* Limestone, intensely hard, splintery, forming with *c.* a prominent feature; *Nerinea eudesii* Morris and Lycett common, and many other shells and ?corals seen in section: 3 ft. ... ... *c.* Limestone, similar to *b*,; *Nerinea eudesii* Morris and Lycett: 2 ft. 9 in. ... Total	6	9
12.	Shale, brown, passing laterally into a well-laminated indurated bed	0	6
13.	Series of 3 to 4 thin limestone beds (predominantly greenish grey owing to associated greenish marl) with marl partings. The lowest bed is impersistent, is associated with much greenish marl, and lies in hollows ...	2	6
14.	Massive block. *a.* Limestone, creamy white, finely oolitic, with a crush of *Modiola* and *Mytilus* along one horizon; *Clypeus muelleri* Wright: 1 ft. 3 in. ... ... *b.* Limestone, similar to *a.*; corals abundant in the lower part, *Epithyris oxonica* Arkell. *Nerita (Neridomus) minuta* J. de C. Sowerby, *Nerinella sp.*, many *Clypeus muelleri* Wright, *Nucleolites sp.*, and fragments of black lignite: 1 ft. 1 in.		

		Ft.	In.
	c. Limestone—a remarkable bed: tough, grey, pinkish and brownish mottled limestone, non-oolitic and of rubbly consistency. The top of the bed has suffered pene-contemporaneous erosion and now the top part is 'knobby', the surface ferruginous, and iron-stained pebbles occur at and in the base of *b*. above: 8 in.		
	d. Limestone, hard, surface ironstained: 1 ft. 6 in. ... ... Total	4	6
15.	Limestone, massive	2	6
16.	Limestone, hard	2	4
17.	Clay, tough, greenish grey, black at the top owing to abundant lignite	1	0
18.	Coral Bed. Limestone, lithographic, cream-coloured, with locally a pinkish tinge, blue-hearted, very massive bed with prominent joints; *Thamnastraea lyelli* Edwards and Haime, *Epithyris* (small species), rhynchonellid common in the uppermost inch or so, *Nerinea eudesii* Morris and Lycett, *Fibula ?variata*, Lycett, *Clypeus muelleri* Wright, *Lima cardiiformis* (J. Sowerby) common, *Astarte sp.*; *Perna sp.*, lignite	3	4

Arkell found lying loose, a mass of *Solenopora*—" the first," he says, " seen in the Oxford district ". It is believed to have come from about the level of 14 *b*.

It is unfortunate that in this section of White Limestones, beds 1 to 8 (inclusive) are lacking in fossils of use for correlation purposes. The limestones of bed 4 are soft and marly and recall the appearance of the unfossiliferous development of the Lower *Epithyris* Bed of the Kirtlington quarry (p. 70).

In the railway-cutting at Hanborough Station the Kemble Beds apparently undergo a rapid change laterally. At the southern end near the bridge, clay, which may be on the horizon of the Bradford Clay, rests on Kemble Beds. Northward along the cutting, however, the clay element expands to 14 ft. and completely replaces the Kemble Beds limestone; the base, to quote Arkell (1931, p. 588): " can be seen to be extremely irregular, with a layer of rounded pebbles, as in the Station Quarry and the Shipton-on-Cherwell Cement Works. Beneath are the same buff pasty limestones and marls with occasional badly-preserved *Gervillia waltoni*, etc., but they are poorly fossiliferous and now ill-exposed." He remarks (1931, p. 587) " The possibility cannot be dismissed that this clay is the equivalent of the Bradfordian and later beds of Bladon Spinney, which have been laid down here after the removal of the Kemble Beds by erosion; but the absence of fossils makes it much more likely that the clay is of the same age as the Kemble Beds, the replacement being a lateral facies-change, like that at Kirtlington and elsewhere." This view receives support from the known similar lateral change in the neighbourhood of Bletchingdon, where, in the Greenhill Quarries, the Kemble Beds are mainly limestone and in Viner's Quarry mainly clay.

The *Aphanoptyxis ardleyensis* Bed and the *Nerinea eudesii* Beds are exposed in a quarry, described by Arkell (1931, p. 606), on the west side of the Chipping Norton road a mile west of Wootton, 2 miles north-west of Woodstock. The numbers in this and the following record correspond to those of the Layshillwood Quarry.

Quarry a mile west of Wootton

		Ft.	In.
8, 9.	*Aphanoptyxis ardleyensis* Bed. Limestone, flaggy, white, compact, fine-grained, the upper part much disturbed, but from 3 ft. below the soil to the base a mass of *A. ardleyensis* Arkell	5	6
10*a*.	Series of three or more limestone beds with marl partings	3	9
b.	Marl, brown, ferruginous; large *Ostrea hebridica* Forbes, radioles of *Hemicidaris bravenderi* Wright common	0	3
11.	*Nerinea eudesii* Beds. *a*. Coral Bed. Limestone, upper surface irregularly waterworn and iron-stained; abundant *Nerinea eudesii* Morris and Lycett, *Nerinella sp.* and a few *Aphanoptyxis*; also *Trigonia pullus* J. de C. Sowerby, *T.* (clavellate sp.), *Eocallista loweana* Morris and Lycett, *Isastraea limitata* Lamouroux, *Chomatoseris porpites* (W. Smith), (= *Anabacia complanata* (Defrance) = *A. orbulites* Lamouroux, *see* Thomas 1935, pp. 428, 429), etc.	1	0
b.	Limestone, massive, top part knobby and surface very ferruginous; abundant *Nerinea eudesii* Morris and Lycett	3	0
c.	Limestone, massive, upper part somewhat marly and oolitic, the lower part sandy to the touch, pinkish, but blue-hearted; *Nerinea eudesii* Morris and Lycett. Upper surface irregularly waterworn	3	4
12.	Sand, brown argillaceous	0	4
13.	Limestone, surface irregularly waterworn ...		

Similar beds are also exposed in a quarry on the north side of the railway east of Grintleyhill Bridge, south of Combe. It is referred to in the Oxford memoir (Pringle 1926, p. 20) and has been described by Arkell (1931, p. 611).

Grintleyhill Bridge Quarry, Combe

		Ft.
8.	Limestone rubble and soil with occasional drift pebbles	3
9.	*Aphanoptyxis ardleyensis* Bed. Limestone, white; *A. ardleyensis* Arkell	2
10*a*.	Limestone, pinkish white	2
b.	Rubble, buff, marly, locally brown, shaly and/or clayey	1
11*a*.	Coral Bed. Limestone, white, the lower part passing into Dagham Stone, locally full of corals:	2 to 3
b.	Rubble, buff, marly	2
c.	Limestone, hard, with an irregularly waterworn, ferruginous surface; occasional *Ptygmatis* (*Bactroptyxis*) *bacillus* d'Orbigny and many lamellibranchs, especially *Trigonia sp.*, difficult to identify: seen for	3

Arkell identified the *Aphanoptyxis ardleyensis* Bed here but not the *Nerinea eudesii* Beds. Although the characteristic gastropod of the latter has not been detected, the beds from the Coral Bed downwards correlate well with the *Nerinea eudesii* Beds of the quarries west of Wootton and at Layshillwood.

According to this correlation the stratum with *Ptygmatis* is the bottom layer of the *Nerinea eudesii* Beds.

About a quarter of a mile north of North Leigh Church, at Fisher's Gate, there are two quarries—Messrs. Breakspear Bros. quarry, where the rock is worked for burning for lime east of the brook, and Messrs. John Werrell and Sons quarry to the west.

The Great Oolite in the former quarry has been described by Arkell (1931, pp. 588, 589).

Breakspear's Quarry, Fisher's Gate, North Leigh

	Ft.	In.
Kemble Beds		
1. Limestone, yellowish white, oolitic, for the most part decalcified to a clayey 'oolite sand,' which contains limestone-fragments of all sizes in the process of dissolution. Locally this is replaced by (1) small-sized oolite gravel with an occasional drift pebble, and (2) gravel composed mainly of drift pebbles; both relics of the Hanborough Terrace let down into the 'oolite sand' ...	5	0
White Limestone		
2. Clay, black and brown with lignite (= bed 7 at Crawley Road Quarry, and 6 at Bladon); up to	0	9
3. Marl and rubble, buff, the lower part full of casts of fossils as in the bed below ...	0	6
4. *Aphanoptyxis bladonensis* Bed. Limestone, hard, cream to grey, crowded with *A. bladonensis* Arkell, *Protocardia subtrigona* (Morris and Lycett) *Astarte fimbriata* Lycett, and *Isocyprina sp.*—the fossils weathering out as casts, but preserved inside freshly broken lumps (= bed 7 at Bladon) ...	0	6
5. Oolite, white	4	0
6. *Aphanoptyxis ardleyensis* Bed. Limestone, hard, white, but locally of a pronounced pinkish tinge; *A. ardleyensis* Arkell abundant in the lower part	1	0
7. Limestone, less compact white; occasional *A. ardleyensis*: seen for	2	6
(According to Dr. Arkell 'A fine specimen of *Nerinea eudesii* from North Leigh in the Oxford University Museum may have come from a lower level than is now worked.')		

The *Aphanoptyxis bladonensis* Bed is typically developed here, crowded with internal casts of the characteristic gastropod, as is its equivalent in The Orchard and The Old White House Inn Quarries at Bladon, and is separated by only 4 ft. of oolite from the *Aphanoptyxis ardleyensis* Bed.

The *Aphanoptyxis ardleyensis* Bed, much expanded and rich in specimens of the gastropod along with many other fossils, is displayed in Dodd's Farm Quarry one mile south-by-east of Leafield, and likewise thickly developed in a quarry on the north side of the road about half-way between Swinbrook and Fulbrook (Arkell 1931, p. 609).

The vast quarries at Milton are now much overgrown. Particulars of the beds, with references to previous literature, have been published (Richardson 1910, pp. 537-542). Arkell (1933*a*, p. 292) has allocated the beds as follows:—White Limestone, 22 ft. seen; Hampen Marly Beds, 17 to 18 ft.; Taynton Stone, 10 ft. seen.

East of Hill Barn (south-west of the Milton Quarries) is the small quarry in the White Limestone in which Arkell (1931, p. 622) detected abundant *Ptygmatis bacillus* (d’Orbigny).

Hanborough Station Quarry, Long Hanborough

	Ft.	In.
Lower Cornbrash		
1. Obovata and Intermedia Zones. Limestone, grey ; *Clydoniceras sp.* : up to	3	0
Wychwood Beds		
2*a*. Clay, grey, with curious insertions of broken Cornbrash limestone and loose specimens of *Cererithyris intermedia*	4	0
b. Limestone, hard, flaggy, brownish grey, fine-grained, sandy, passing laterally into films of shelly oolitic limestone : 8 in. to... ...	1	4
c. Clay, grey : 3 in. to	1	0
Kemble Beds		
3*a*. Limestone with waterworn ferruginous surface, markedly false-bedded with irregular partings, much lignite, occasional fish teeth and fragments of bones	12	0
b. Limestone, in part white lithographic stone and in part greyish oolite with at the base a layer of oolitic marl or rottenstone with lignite and pebbles of limestone	1	0
Marked plane of erosion		
White Limestone		
4. Marl, buff, fine-grained, locally hardened to a tough, compact limestone, with ill-preserved fossils, mostly casts, and plant-like remains (compare bottom beds in Bladon Spinney) ; *Aphanoptyxis bladonensis* Arkell, *Gervillia waltoni* Lycett, *Isocyprina sp.*, *Modiola imbricata* J. Sowerby, *Beushausenia sp.* 0 to	1	0
5. Marl, soft, buff to grey, as above with *A. bladonensis* and *G. waltoni* : 10 in. to ...	1	4
6. Limestone, buff, fine-grained, same as bed 4, and apparently the same fossils	1	6
7. Marl, soft, buff, full of ill-preserved lamellibranch casts, *Isocyprina sp.* abundant ...	0	6
8. Limestone, hard, grey, only top seen ; said to be blue-hearted	2	6

As will be seen on reference to the observations of Woodward, (1894, pp. 319, 373), Pringle (1926, p. 22) and Arkell (1931, pp. 586, 587) there has been a diversity of opinion as to the classification of the rocks exposed.

Concerning the curious insertions of Cornbrash in the clay, Pringle remarks : “ Quarrying operations in this pit frequently expose curious patches of Cornbrash which have dropped down swallowholes in the grey clay . . . ” Arkell, in his account of the section, assigns beds 2*a*, *b*, and *c* above to the Kemble Beds. A feature of this section is the markedly false-bedded nature of the Kemble Beds limestones (*see* Richardson 1935, p. 326). The beds below the marked plane of erosion are not now exposed : the account given above is taken mainly from the paper by Arkell, who describes them under the subdivisional name of *Fimbriata-waltoni* Beds. They appear to be comparable in a general way with beds 1 and 2 of the Layshillwood Quarry and with beds 7-9 of the Crawley Road Quarry, Witney.

The quarry in the spinney 500 yds. north-east of Bladon has not been worked for some time and the section is rapidly deteriorating. It has, however, been described by several geologists, the last being Arkell (1931, pp. 582, 583): the appended record is based on his description.

The Spinney Quarry, Bladon

	Ft.
Lower Cornbrash	
Obovata and Intermedia Zones. Limestone, rubbly: *Cererithyris intermedia* (J. Sowerby), etc.: seen for	4
Wychwood Beds	
Limestones, false-bedded, flaggy, oolitic, broken-shell, in places of a sandy texture, with much interlaminated clay, and passing down irregularly into a band of grey clay about 3 ft. thick	12
Bradford Fossil Bed. Impersistent band of argillaceous limestone with abundant *Rhynchonella sp.*, as at Islip, also small examples of *Exogyra crassa* (Smith), *Modiola imbricata* J. Sowerby, and *Cidaris* spines. As remarked by Pringle (1926, p. 23), " it is highly probable that [this] argillaceous limestone with several species of Rhynchonellids . . . corresponds to a bed of similar lithology and fauna in the Islip Quarry ": 0 to	1
Kemble Beds	
Clay grey: 0 to	2
Limestone, buff and blue, white-weathering, indistinctly false-bedded, oolitic, coarse-grained above becoming more fine-textured below, and resembling the same beds at Islip, etc.	10
White Limestone	
Compact shelly limestone with plant fragments ...	4½
Marly clay, seen to	2½

A feature of this section is the development of much limestone between the Cornbrash and Bradford Fossil Bed. Much of the 4 ft. 9 in. of deposit observed by Hull (1859, p. 24) between " soft white oolite, false-bedded," 10 ft., obviously Kemble Beds, and the Cornbrash (5 ft. seen) " in a quarry in Blenheim Park, opposite Old Woodstock," was limestone. The White Limestone beds of Spinney Quarry were seen by Pringle: Arkell identified them with his *Fimbriata-waltoni* Beds, and they may be compared in a general way with those seen immediately below the Kemble Beds in the Hanborough Station Quarry.

The lower 5 ft. of the Kemble Beds can be seen in a small quarry in an orchard on the opposite side of the road to Spinney Quarry. They rest on a dark green clay (0 to 3 ins.), and this in turn on the *Aphanoptyxis bladonensis* Bed (9 ins. to 1 ft. 3 ins.), below which white limestone is exposed to a depth of 2 ft. 3 ins. The *Aphanoptyxis bladonensis* Bed is crowded with specimens of the characteristic gastropod and " associated," to quote Arkell, " with all the characteristic lamellibranchs of the *Fimbriata-waltoni* Beds."

Behind the Old White House Inn, in Bladon, a quarry has been extended and shows:—

The Old White House Inn Quarry, Bladon

	Ft.	In.
Kemble Beds		
1. Clay, grey, and pale grey marl: seen for ...	2	6
2. Limestone, grey, oolitic, false-bedded, flaggy	3	6
3. Marl, yellow	0	6

	Ft.	In.
Kemble Beds—*continued*		
4. Limestone, creamy white, somewhat argillaceous, but hard and irregularly flaggy ...	3	6
5. Marl, yellow, locally indurated	0	6
White Limestone		
6. Clay, dark greenish and black; a regular bed in the northern face of the quarry, 5 in. thick, but dies out southward in the western side: 0 to	0	8
7. *Aphanoptyxis bladonensis* Bed. Marl and rubble passing into limestone; *A. bladonensis* Arkell, *Astarte fimbriata* Lycett, *Isocyprina sp.*: 0 to	0	8
8. Limestone, top 'knobbly' and ferruginous, but otherwise white and buff and oolitic, in places massive but on weathering breaks down to a rubbly friable oolite. Arkell records (1933*b*, p. 180) 'many *Eocallista* and *Isocyprina*; also *Trigonia pullus* J. de C. Sowerby, *Fibula variata* Lycett, *Ptygmatis sp.*, *Pteroperna sp.* Some lignite'	3	10
9. Coral Bed. Limestone, greyish white, non-oolitic; lower foot crowded with *Thamnastraea lyelli* Edwards and Haime; *Epithryis oxonica* Arkell, *Lima cardiiformis* (J. Sowerby)	2	3
10. Middle *Epithyris* Bed. Marl, brown, shaly, and chocolate-coloured clay passing locally into earthy limestone and attached in places to the Coral Bed. Locally, abundant *Ostrea hebridica* Forbes and occasional crushed *Epithyris oxonica* Arkell; *Hemicidaris* spines; average	0	2
11. Clay lens, black, lignite. Seen, according to Arkell (1933*b*, p. 180), in S.W. corner of quarry, but now totally concealed by tipped rubbish: 0 to	0	6
12. Limestone, in two layers, white and buff, oolitic to lithographic, upper layer bored by annelids, surface water-worn and ferruginous	2	0
13. Limestone, similar to 12; *Aphanoptyxis sp.* ...	0	8
14. Limestone, similar to 12	1	0
15. Limestone in two layers; *Nerinea eudesii* Morris and Lycett is locally abundant ...	3	0
16. Limestone, with irregularly waterworn surface, pinkish, rubbly	1	6
17. Limestone, hard, with brown ferruginous surface: seen for	1	0

Arkell (1931, p. 585) assigned the beds numbered 6 to 9 (inclusive) above to his *Fimbriata-waltoni* Beds and commented on the remarkably close resemblance of bed 10 to the Middle *Epithyris* Bed at Shipton on Cherwell and Greenhill. On the enlargement of the quarry and the opening of Tolley's New Quarry on the east side he revised his views as to the correlation of the beds: later (1933*b*, pp. 177-183) he correlated the Coral Bed (9 above) with the Upper *Epithyris* Bed of the Cherwell Valley, etc., extended downwards the lower limit of the Kemble Beds so as to embrace as the basal deposit the Coral Bed, and queried as the representative of his *Fimbriata-waltoni* Beds the "Lenticle of black clay. . . ; perhaps represented in rest of quarry by a parting of brown marl full of *Ostrea sowerbyi* [*hebridica*] (2-3 ins.) : 0 to 6 in."

Arkell has informed the writer that he agrees that bed 6 above (or 7 of his record) is correlative with bed 7 of the Crawley Road Quarry, Witney, the Bladon Coral Bed with the Witney Coral Bed (11 at Witney), and that he is inclined to revert to the correlation of the beds in The Old White House Inn Quarry as indicated in his 1931 paper.

The present writer, who examined the Bladon section mostly in the extension of the quarry in the direction of that in the orchard, has not seen the black clay-lens (bed 11 above), but in the Crawley Road Quarry similar clay overlies the Middle *Epithyris* Bed.

On the east side of the road, opposite the Orchard Quarry, Bladon, is one opened by Mr. H. A. Tolley, junr., in January, 1932 (*see* Arkell 1933*b*, pp. 180, 181).

Tolley's New Quarry, Bladon

	Ft.	In.
? Wychwood Beds		
Limestone, platy, grey, mainly composed of large white ooliths in a matrix of dark comminuted oysters; extremely false-bedded: seen in pockets to ...	3	6
Clay, light grey, and oolitic marl ...	1	0
Kemble Beds		
Limestone, false-bedded, same as above: 2 ft. 6 in. to ...	4	0
Clay, grey, soapy, and pale grey marl ...	4	8
Limestone, false-bedded as in the other (Ole White House Inn) quarry ...	7	0
White Limestone		
6. Clay, dark green and chocolate, with much lignite: also (?) *Ceteosaurus* bones. Locally replaced by a lenticular band of rusty-coated, black-centred 'Forest Marble', 0 to 1 ft. thick ...	1	6
8. Limestone as in the other quarry...	4	0
9. Coral Bed as in the other quarry with large *Nautili* ...	1	0
10. Middle *Epithyris* Bed. Marl, brown; abundant *Ostrea hebridica* Forbes ...	0	2
Lime stones, as in the other quarry: seen for ...	6	6

The top beds queried as Wychwood Beds may be Kemble Beds: this would account for the absence of Bradford Fossil Bed fossils from this quarry while they abound in the neighbouring Spinney Quarry. It is easy to compare certain beds seen here with their equivalents in The Old White House Inn Quarry, but it will be at once observed that the *Aphanoptyxis blandonensis* Bed is absent. The dark green clay, bed 6, according to Arkell "does not contain the *fimbriata-waltoni* fauna" but, it contains bones of (?) *Ceteosaurus* as does the bed at Kirtlington (p. 70) with which it is here correlated.

In an old quarry near Campsfield Farm, east of Woodstock, Arkell (1931, p. 582) noted Cornbrash resting on Forest Marble limestones similar to those in the Bladon Spinney Quarry. The latter were 12 ft. thick, and parted from Kemble Beds (4 ft. seen) by clay, 8 in. to 1 ft. 3 in. thick, which he regarded as the equivalent of the Bradford Fossil Bed of Bladon.

To the north of Shipton on Cherwell 'Gibraltar Quarry,' described by Odling (1913, pp. 496-498), has now been engulfed in the Oxford Cement Company's Quarry. The following record is based on Arkell's description (1931, pp. 579, 580).

Oxford Portland Cement Company's Quarry.
Shipton on Cherwell

	Ft.	In.
Cornbrash. In field immediately above the quarry		
Wychwood Beds		
1. Clays, greenish grey, predominating at the northern end, with subordinate beds of thinly laminated, sandy, false-bedded typical Forest Marble, which gradually replace the clays to a variable extent in other parts of the quarry. About 6 ft. to...	10	0
Kemble Beds		
2. Limestone, false-bedded, hard, white, blue-hearted, coarsely oolitic, locally split up by thick lens of dark-blue, shaly clay: about	10	0
3. Upper *Epithyris* Bed. Limestone, similar to 2, passing laterally southwards into lithographic limestone; abundant *Epithyris oxonica* Arkell, *Modiola imbricata* J. Sowerby, etc.: 2 ft. to	3	0
[Plane of erosion with a few pebbles]		
White Limestone		
4. Marl, green, lignitiferous, black and shelly at the base, full of white papery *Gervillia waltoni* Lycett, etc., 3 ft. thick at the northern end, passing southwards into a 6-in. band of white pellets as at Greenhill: 4 in. to	3	0
5. Limestone, greenish grey, compact, argillaceous, weathering soft; crowded with *Gervillia waltoni* Lycett, *Astarte fimbriata* Lycett, *Protocardia subtrigona* Morris and Lycett, *Corbula hulliana* Morris, *Modiola imbricata* J. Sowerby, *Eonavicula sp.*, *Aphanoptyxis bladonensis* Arkell, *Amberleya nodosa* (J. Buckman), *Nerita minuta* J. de C. Sowerby. Expands northward from 6 in. to	1	0
6. Clay, dark green with white pellets as at Greenhill: 1 ft. 6 in. at southern end thinning northward to	0	9
7. Limestone, hard, unfossiliferous, thins northward: 0 to	0	10
8. Middle *Epithyris* Bed. Marl, brown, ferruginous; abundant flattened *Epithyris oxonica* Arkell and towards the southern end, *Ostrea hebridica* Forbes. In places, pebbles in the base consisting of rolled fragments of limestone and corals, as at Lower Greenhill, the corals identified by Mr. Odling (his bed 9) as *Isastraea limitata* Lamouroux and *Thasmnatraea lyelli* Edwards and Haime	0	9
[Plane of erosion]		
9. Limestones, creamy white, compact. In places the Lower *Epithyris* Bed is typically represented, while in others the white limestone is free from Epithyrids and the surfaces of the blocks are strewn with *Eocallista islipensis* (Lycett), etc., as at Kirtlington: seen to about	6	0

Owing to the great length of this quarry it is possible to see clearly the changes in lithology that the Kemble Beds undergo laterally: to quote Arkell, "In places the beds are irregularly laminated, somewhat sandy, and split up by enormous clay seams, so that they much resemble Forest Marble, but in other parts of the section they pass laterally into more massive, blue-hearted, white, coarsely-oolitic detrital limestones, indistinguishable from the Kemble Beds of Islip and Kirtlington; while thick lenticles of dark slate-coloured, shaly clay like that of Kirtlington develop locally. Finally, at the south end, the basal portion passes gradually into a solid block of typical Fossiliferous Cream Cheese, crowded with *Epithyris exonica* and other fossils, so that correlation with Kirtlington is complete." Beds 4, 5, 6 and particularly 5, are comparable with beds 7, 8 and 9 in the Crawley Road Quarry, Witney (p. 45).

East of the River Cherwell at Enslow Bridge is a cape-like projection of rising ground bearing the name 'Gibraltar' through which the Oxford and Birmingham Railway passes. At the northern end of the cutting is Bletchingdon (formerly Kirtlington) Station.

A large quarry close to the station, probably the original 'Gibraltar Quarry,' (*see* Phillips 1871, p. 247) has long been abandoned, but east of the southern end of the cutting two quarries are still intermittently worked. They are referred to in recent geological literature as the 'Upper' and 'Lower Greenhill Quarry,' but on a plan in the possession of the quarry owner they are marked 'Gibraltar Quarry, No. 1' and 'No. 2' respectively. The 'marble' that attracted Plot's attention and probably suggested to William Smith a name for one of his formations—the Forest Marble, was obtained hereabouts.

The area is also of interest for the comparative abundance of bones of *Ceteosaurus*, etc., in dark green clay on the horizon of bed 6 of both the Oxford Cement Company's quarry and of the old Kirtlington Cement Works (p. 70). The first specimens of *Ceteosaurus* were obtained from the railway-cutting in 1848 by Strickland and included a femur 4 ft. 3 in. long. Twenty years later Phillips (1871, pp. 247-251) obtained other remains (including a femur 5 ft. 4 in. long) of this huge saurian to which he gave the name *Ceteosaurus oxoniensis*.

The Great Oolite beds displayed in the railway-cutting were described by Phillips (*in* Hull 1859, p. 20; 1860, p. 118; 1871, p. 154), but now are only poorly exposed. It is clear from Phillips's description, however, that the beds are similar to their equivalents in the Lower Greenhill Quarry and at the old Kirtlington Cement Works (p. 70).

The sections in both Greenhill quarries have been described by Odling (1913, pp. 494-496); combined, to make one record, by Pringle (1926, p. 24); and that in the lower quarry, in detail, by Arkell (1931, pp. 581, 582).

Upper Greenhill Quarry, Bletchingdon

	Ft.	In.
? Kellaways Beds (disturbed) (*see* p. 77)	6	1
Cornbrash (*see* p. 77)	10	4
Wychwood Beds		
1. Clay, pale bluish grey, incipiently shaly with a layer of white claystone at the top: 0 to	1	3
Kemble Beds		
2. Limestones with shale partings, sandy and blue-hearted: up to	4	0
3. Clay, greenish grey	1	0
4. Limestones, false-bedded, mostly blue-hearted; some white, some sandy with problematical markings resembling a large flat lamellibranch (as in the quarry near 'The Pit,' Kencott), some oolite	6	0

The similarity of the Kemble Beds to their equivalent in the south-western part of the district north of Kencott and around Brize Norton may be stressed. An interesting feature to be observed here is the occurrence of ripple-marks on the *inclined* surfaces of the false-bedded, or obliquely-laminated, strata.

Lower Greenhill Quarry, Bletchingdon

	Ft.	In.
Cornbrash	1	6
Wychwood Beds		
1. Clay, greenish-grey with thin impersistent laminae of limestone about the middle: up to	5	0
Kemble Beds		
2. Limestones, white, oolitic, false-bedded ...	4	0
3. Clay, greenish-grey, partly replaced the bed above: 3 ft. to	1	0
4. Limestones similar to (4) of Upper quarry ...	6	0
[Plane of erosion]		
White Limestone		
5. Marl, brown, eroded away at both ends of the quarry; abundant *Gervillia waltoni* Lycett and plant markings: 0 to	1	1
6. Clay, green, with lignite, the top pale and full of white pellets	3	0
7. Middle Epithyris Bed. Marl, brown, oolitic, full of crushed *Epithyris oxonica* Arkell, with large *Ostrea hebridica* Forbes, a conspicuous pebble-bed at base, with bored and rolled pieces of limestone up to 8 in. in length: 1 ft. to	1	6
[Plane of erosion]		
8. Limestones, hard, compact, grey to white, blue-hearted in two courses; *Natica intermedia* Morris and Lycett, *Mytilus sublaevis* J. de C. Sowerby, *Protocardia lingulata* (Lycett), epithyrids at the base (= beds 8-10 at Kirtlington)	6	0
9. Lower *Epithyris* Beds. *a*. Limestone, white, ‘lumpy,’ crumbly; crowded with *Epithyris oxonica* Arkell, *Lima cardiiformis* (J. Sowerby), and *Modiola imbricata* J. Sowerby (= 11 *pars* at Kirtlington)	3	0
b. Limestone, white, in three courses (= 11 *pars* at Kirtlington)	3	6

It will be observed that here, as a rule, and at the old Kirtlington Cement Works quarry the Middle *Epithyris* Bed is separated only by dark clay from the Kemble Beds, whereas at The Old White House Inn Quarry, Bladon, Crawley Road Quarry, Witney, and probably Eton College Quarry, Asthall, white limestones intervene. From a study of these and certain other sections it would appear that in many places west of the Cherwell valley the ‘ clay-bed ’ becomes split up by the local development of limestones, including the *Aphanoptyxis bladonensis* Bed and Coral Beds of Bladon and Witney.

Viner's Quarry, Kirtlington

	Ft.	In.
Kemble Beds		
1. Limestones, flaggy, with white-limestone inclusions: probably slipped a little: up to	2	0

	Ft.	In.
Kemble Beds—*continued*		
2. Clay, grey and white	6	0
3. Upper *Epithyris* Bed. Limestone, white, crowded with *Convexastraea waltoni* Edwards and Haime, *Thamnastraea lyelli* Edwards and Haime, *Modiola imbricata* J. Sowerby and *Epithyris oxonica* Arkell; also *Cerithium sp.*, *Natica intermedia* Morris and Lycett, *Nerita minuta* J. de C. Sowerby, *Trochotoma obtusa* Morris and Lycett, *Parallelodon (Beushausenia) transversum* (Morris and Lycett), *Pteroperna costatula* (Deslongchamps) and *Cladophyllia babeana* Edwards and Haime: 1 ft. to 4 in. thickening to the north-westward to	4	0
White Limestone		
4. Clay, tough, green and black, with nodular masses of grey limestone near the top and a rusty layer at the base	2	3
5. Clay, grey... ... ... (To the northwestward 4 and 5 are reduced to a 3-in. layer).	1	6
6. Limestone, hard, white, argillaceous: seen for	2	0

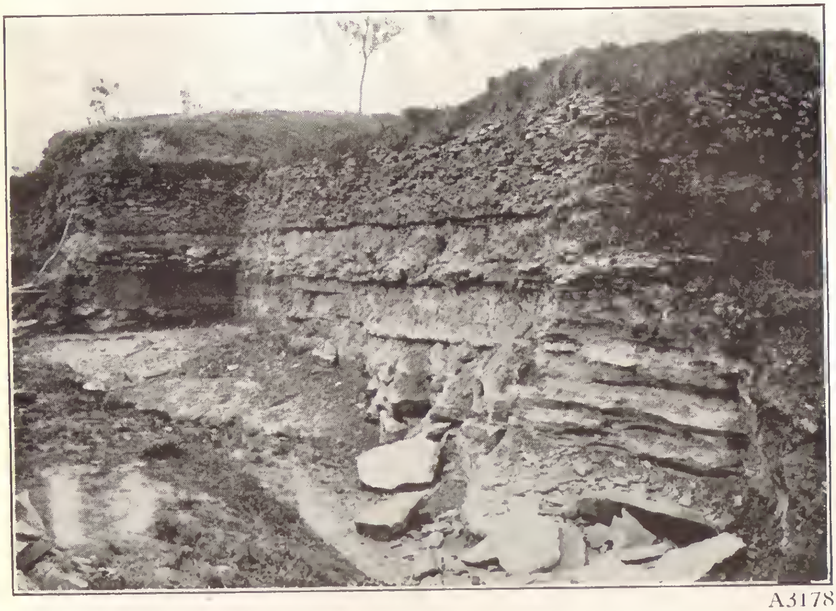
The Upper *Epithyris* Bed is remarkably fossiliferous. The clay (4 and 5) is similar to the green clay layer, bed 2, in the Eton College Quarry, Asthall (p. 48) and bed 7 in part of the Crawley Road Quarry, Witney (p. 45). The rapid (for the Greenhill Quarries are only about half a mile away) replacement of the Kemble Beds by clay supports the view that much of the clay near Hanborough Station is of Kemble Beds age.

The fine quarry of the Kirtlington Cement Works (Sheet 218) has been described by Odling, (1913, pp. 493, 494) Arkell (1931, pp. 570-572) and Douglas (*in* Douglas and Arkell 1932, pp. 123, 124). The following account is based on Arkell's who, however, then placed bed 3 in the Wychwood Beds.

Cement Works, Kirtlington

	Ft.	In.
Cornbrash (*see* p. 78)	9	9
Wychwood Beds		
1. Clay, grey and buff, with some thin, irregular, hard bands, *Ostrea hebridica* Forbes and small lamellibranch casts	5	0
2. Clay, dark grey; a layer of large *Ostrea hebridica* Forbes at the top	2	3
Kemble Beds		
3. Limestone, yellowish, flaggy, locally marly and 'shaly,' oolitic, with occasional inclusions of white lithographic limestone; ripple-marks, rain-pits, *Camptonectes laminatus* (J. Sowerby), *C. rigidus* (J. Sowerby), *Placunopsis sp.*, etc. Thickening northwards from 2 ft. to	3	0
[Non-sequence and slight unconformity]		
4. Clay, grey-blue, with three pale mudstone layers, one at the bottom; unfossiliferous except for abundant *Placunopsis socialis* Morris and Lycett. To the north the lower half passes laterally into limestone 7 ft. 3 in. Maximum at southern end	6	6

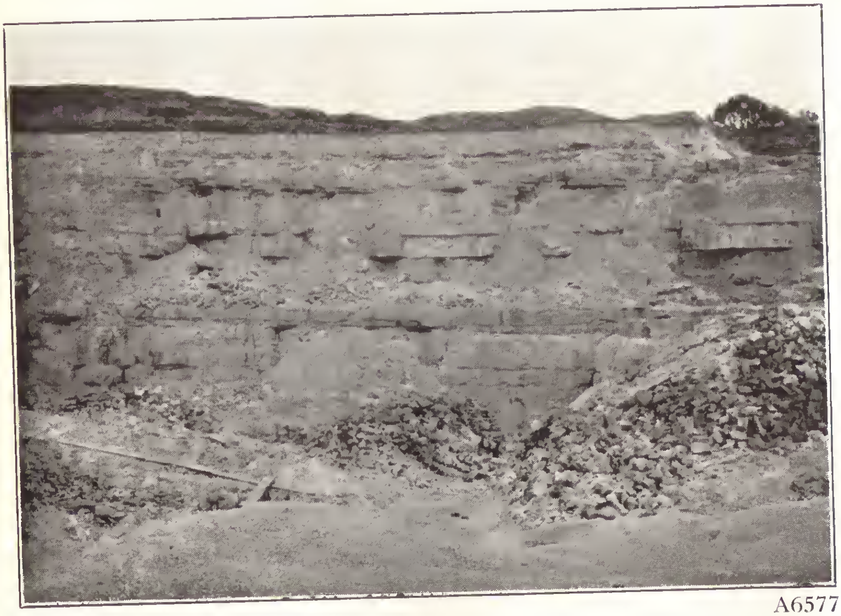
		Ft.	In.
5.	Upper *Epithyris* Bed. Limestone, at northern end an extremely hard white blue-hearted lithographic rock crowded with *Epithyris oxonica* Arkell and *Modiola imbricata* J. Sowerby; also *Cyathopora pratti* Edwards and Haime, *Fibula variata* Lycett, *Camptochlamys obscura* (J. Sowerby), *Lima cardiiformis* (J. Sowerby), *Navicula* (*Eonavicula*) (Rollier) and *Pinna odlingi* Arkell. Passes locally into unfossiliferous oolite. At south end 4 ft., at north end … … … …	7	3
	White Limestone		
6.	Clay, grey-green to greenish black, with some white pellets at top; bed largely made up of lamellibranchs in the following order of abundance: *Gervillia waltoni* Lycett; *Astarte fimbriata* Lycett; *Corbula hulliana* Morris, *Protocardia subtrigona* (Morris and Lycett); also *Amberleya nodosa* (J. Buckman) and *Nucula waltoni* Lycett … … …	3	6
	At the base of this bed on the eroded surface of 8 where 7 is absent occur lignite and bones of *Ceteosaurus oxoniensis* Phillips … …		
7.	Middle *Epithyris* Bed. (= Odling's First *Terebratula* Bed 7). Marl, brown; abundance of *Ostrea hebridica* Forbes and occasional crushed *Epithyris oxonica* Arkell: 0 to …	0	3
	Locally a thin layer of corals occurs beneath the Epithyrid Bed.		
	[Plane of erosion]		
8.	Limestone, hard, blue-hearted … … …	3	0
9.	Marl … … … … … …	0	9
10.	Limestone, similar to 8; Epithyrids abundant: 2 ft. 9 in. to … … … … …	3	0
11.	Lower *Epithyris* Bed. Limestones, white, obliquely bedded. At west end of pit, the whole 8 ft. a mass of *Epithyris oxonica* Arkell. *Lima cardiiformis* (J. Sowerby), *Modiola imbricata* J. Sowerby, etc. Thins out eastwards from bottom upwards, its place being taken from beneath by lenticular limestones, Some of the beds abound in ? *Eocallista islipensis* (Lycett), along with *Natica*, *Nautilus dispansus* Morris and Lycett. Over-all thickness constant … …	8	0
12.	*Aphanoptyxis ardleyensis* Bed. Limestone, even-bedded; *Aphanoptyxis ardleyensis* Arkell locally abundant; a few *Nerinea eudesii* Morris and Lycett, *Fibula variata* Lycett, and lamellibranchs, chiefly *Eocallista*: 1 ft. 6 in. to … … … … …	2	0
13.	*Nerinea eudesii* Beds. Limestones in three courses; abundant *Nerinea eudesii* Morris and Lycett; also numerous *Trigonia pullus* J. de C. Sowerby, *T. flecta* Morris and Lycett, *Modiola imbricata* J. Sowerby, *Eocallista* and *Isocyprina sp.*, *Protocardia lingulata* (Lycett), *Navicula sp.*, *Nucleolites sp.*, *Hemicidaris sp.*, and *Chomatoseris porpites* (Smith)	5	6



A3178

A.—ISLIP QUARRY.

Cornbrash on Forest Marble.



A6577

B.—KIRTLINGTON CEMENT WORKS (ABANDONED) QUARRY.

Section showing, in descending sequence, Cornbrash, Wychwood and Kemble Beds (' Forest Marble ') and White Limestone (Great Oolite).

Bed 6 is comparable with beds 4-6 at Shipton on Cherwell and 7-9 in the Crawley Road Quarry, Witney. The main horizon for Ceteosaurian remains appears to be between the clay and the Middle *Epithyris* Bed, although here at Kirtlington and elsewhere the remains are often enclosed by the clay.

According to Arkell, the Middle *Epithyris* Bed at the southern end of the quarry has the same aspect as at Kirtlington [now Bletchingdon] Station where Phillips (1860, p. 117) noted that the oolite below had a " waterworn surface, sometimes drilled by *Lithodomus*, covered by drifted *Ostreae* and *Terebratula maxillata.*"

In the Oxford Portland Cement Company's Quarry the Middle *Epithyris* Bed rests on the limestones belonging to the Lower *Epithyris* Bed, but at Kirtlington Cement Works two limestones and a marl, collectively 6 ft. 9 in. thick, intervene. They do not represent an expanded *Aphanoptyxis bladonensis* Bed because that bed is post-Middle *Epithyris* Bed.

The Lower *Epithyris* Bed changes laterally and it will be realised that care has to be exercised in identifying the bed. It is noteworthy that here, as elsewhere, where the terebratulids are deficient, lamellibranchs, such as *Modiola imbricata*, *Lima cardiiformis* and *Eocallista islipensis* are locally of frequent occurrence, and assist in supporting tentative correlations.

Islip Quarry is situated near The Grange, 400 yds. south-west of the Islip Church and south of the railway. Specimens from the richly fossiliferous Bradford Fossil Bed have been noted by numerous authors and the section described as below, is by Arkell (1931, pp. 576, 577).

Islip Quarry

	Ft.	In.
Lower Cornbrash		
Limestone, compact; *Cererithyris intermedia* (J. Sowerby), *Pseudomonotis echinata* (Smith): seen for	1	0
Rubble, marly	0	4
Limestone, rubbly; *Ornithella obovata* (J. Sowerby), common, *Chlamys vagans* (J. de C. Sowerby), *Entolium demissum* (Morris and Lycett *non* Phillips), *Limatula cerealis* Douglas and Arkell, *Pleuromya decurtata* (Phillips), *Pseudomonotis echinata* (Smith), *Pygurus michelini* Cotteau, etc.	2	0
Clay, brown, marly; *Ornithella obovata* (J. Sowerby)	0	3
Limestone, rubbly; *Cererithyris intermedia* (J. Sowerby) and *Ornithella obovata* (J. Sowerby), both rare, and many other fossils as in the limestone above the clay	0	3
Wychwood Beds		
Clay, grey, and impersistent limestones	1	0
Limestone, false-bedded, fissile, brown, blue-centred, sandy, ripple-marked and rain-pitted; *Camptonectes laminatus* (J. Sowerby), *C. rigidus* (J. Sowerby), *Gervillia islipensis* Lycett, *Corbula islipensis* Lycett, *Acrosalenia* spines, etc. ...	1	0
Clay, grey, laminated	2	0
Bradford Fossil Bed. Limestone, grey, fine-grained, soft, argillaceous, a mass of fossils especially rhynchonellids of at least four species, also *Dictyothyris coarctata* (Parkinson), *Digonella digona* (J. Sowerby), *Eudesia cardium* (Lamark), *Cidaris bradfordensis* Wright, *Lima cardiiformis* (J. Sowerby) (abundant). *Convexastraea waltoni* Edwards and Haime, *Terebellaria ramosissima* (Lamouroux)	0	6

	Ft.	In.
Kemble Beds		
Clay, grey ; *Placunopsis socialis* Morris and Lycett	0	6
Limestone, thickly false-bedded, homogenous, grey, oolitic, blue-hearted : seen for	5	0

According to Pringle (1926, p. 27) the thickness of the grey limestone (Kemble Beds) is 8 ft., and a well in the quarry proved blue and greenish clay with lignite below. As remarked by Arkell (1931, p. 577), it is probable part of the quarry once " extended down into this clay (which we may hazard is the *Fimbriata-waltoni* Beds [bed 6 of Kirtlington], since the list of fossils collected by Whiteaves and reprinted in the Geological Survey Memoir contains the following highly suggestive species, which are no longer to be obtained :— *Gervillia waltoni, Astarte ' angulata '* (? *fimbriata*), *Protocardia subtrigona,* and *Amberleya nodosa.*"

Some Thicknesses of the Cornbrash, Forest Marble and Great Oolite

Formations	Subdivisions	Western Margin	Mid-Northern Part	North-Eastern Part
Cornbrash	—	11 ft.	8ft. 6in. - 11ft.	10 - 14ft.
' Forest Marble '	Wychwood Beds	Furzey Hall Boring, Filkins (Sheet 235) : 27ft. The Pitt, Kencott : 6ft. Brize Norton : 2 - 3ft.	East End Quarry, North Leigh : 3ft.	0 - 7ft. 3in.
	Kemble Beds	21 ft.	12 ft.	11 - 13ft.
Great Oolite	White Limestone	? About 60ft.	54 - 60ft.	? 30ft.
	Hampen Marly Beds	Milton Quarries, 17ft. 4in.	About 25ft.	Tackley[1] : about 20ft.
	Taynton Stone	About 11ft. 6in.	Stonesfield : 25ft.	? Up to 17ft.

[1] (Hull 1859, p. 21)

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CHAPTER VI

CORNBRASH

By L. Richardson

THE outcrop of the Cornbrash extends across the district from south-west to north-east. Locally it is comparatively broad, and beyond the main outcrop there are outliers as at Langley, Leafield, Ramsden, Wilcote and Combe. Except for the Lagenalis Zone, which as a rule is brown marly clay, the formation consists of tough, rubbly, shelly limestones with occasional marly partings. The marl seams are not oolitic, except locally at the base, where the included ooliths may have been derived, and the beds exhibit little lithic or faunal variation throughout the district. The formation varies between 8 and 14 ft. and is divisible by means of its ammonite fauna into two parts, Upper Cornbrash characterized by forms of the *Macrocephalites* group and Lower Cornbrash characterized by *Clydoniceras*. Each part is further divisible by means of brachiopods:—

Upper Cornbrash

Lagenalis Zone.—Usually brown marly clay with *Microthyris lagenalis* (Schlotheim). At Long Hanborough, 4 in. thick: Upper Greenhill Quarry, 1 ft. 6 in.; and, according to H. B. Woodward, in a cutting of the Woodstock Branch Railway, limestones, 3 ft. 8 in. thick.

Siddingtonensis Zone.—Hard, compact limestone with *Microthyris siddingtonensis* (Walker) and an occasional ammonite of Macrocephalitoid or Perisphinctid type.

Lower Cornbrash

Obovata Zone.—Usually rubbly limestone associated with some marl with
(a) *Astarte-Trigonia* Bed, rich in lamellibranchs above and
(b) Limestones in which *Ornithella obovata* (J. Sowerby) is more abundant forming the lower part.

Intermedia Zone.—Limestones, etc., packed with *Cererithyris intermedia* (J. Sowerby).

Details

The basal 2 ft. of the Cornbrash is seen at the top of an old quarry two-thirds of a mile north by east of Kencott church. The limestone, an exception to the rule, is sparsely oolitic: the ooliths may have been derived from the destruction of white oolitic limestones belonging to the Kemble Beds such as Hull saw immediately underlying Cornbrash near Rock Farm, Carterton (p. 42).

Tweed's Well (p. 41) and a well at a house opposite the Beehive Inn, both in Carterton, went through soil, 1 ft., Cornbrash, 6 ft., and Wychwood Beds (clay), 20½ ft. and 10 ft. respectively.

The Siddingtonensis Zone, consisting of grey flaggy limestone, poorly fossiliferous, but containing *Microthyris siddingtonensis* (Walker), *Aptyxiella lineata* Blake, *Natica* cf. *cincta* (Phillips), *Lopha marshii* (J. Sowerby), *Pteria (Oxytoma) expansa* (Phillips), *Pseudomonotis echinata* (Smith), *Modiola bipartita* (J. Sowerby), *Chlamys vagans* (J. de C. Sowerby), and *Gresslya peregrina* (Phillips), is exposed to a depth of 2 ft. in a shallow quarry about halfway between Carterton cross-roads and Marsh Haddon Farm (Douglas and Arkell 1928, p. 132).

Part of the Obovata Zone, very fossiliferous rubbly limestone associated with some marl, and a thin development of the Intermedia Zone, packed with *Cererithyris intermedia* (J. Sowerby), are seen at Brize Norton.

Ducklington Lane Quarry, Witney

		Ft.
Lower Cornbrash		
Obovata Zone.	Limestone, hard, flaggy, poorly fossiliferous; *Ornithella obovata* (J. Sowerby), *Pseudomonotis echinata* (Smith) *Chlamys vagans* (J. de C. Sowerby). *Pholadomya phillipsi* Lycett	3
	Rubble, loose yellow, and marl; *Ornithella obovata* (J. Sowerby) abundant, *Pseudomonotis echinata* (Smith), *Lima (Pseudolimea) duplicata* (J. de C. Sowerby), *Limatula cerealis* Douglas and Arkell, *Chlamys vagans* (J. de C. Sowerby), *Cardium buckmani* Morris and Lycett, *Anisocardia minima* (J. Sowerby), *Pleuromya decurtata* (Phillips), *Nucleolites clunicularis* (Smith), *Holectypus depressus* Leske, *Pygurus michelini* Cotteau, and *Clydoniceras sp.*	2
	Limestone, hard, cream-coloured; *Ornithella obovata* (J. Sowerby), *Pseudomonotis echinata* (Smith), and *Trigonia sp.* ...	2
Intermedia Zone.	Limestone with pockets of fossils; *Cererithyris intermedia* (J. Sowerby) (abundant)	1
	Wychwood Beds (*see* p. 44): 9ft. 6in. to	10
	Kemble Beds (*see* p. 44): seen for ...	8

The above description is based on Douglas and Arkell (1928, p. 132)

The Cornbrash has a considerable extent in the vicinity of the Aerodrome near Witneypark Farm, but the shallow quarries hereabouts are overgrown.

A few small exposures may be seen by following the brook north-eastwards from Newland. A well a quarter of a mile south of Middlefield Farm encountered Cornbrash, 9 ft., Wychwood Beds clay 12 ft., and ? Kemble Beds 2 ft. (*see* Tiddeman 1910, p. 87).

A well sunk in 1933 in the south-western angle made by the cross-roads half a mile south of Hailey Church revealed the full thickness of the Cornbrash.

Well near Hailey

	Thickness Ft.
Heavy clay soil with drift pebbles, passing down into ...	½
Kellaways Beds	
Clay, bluish grey and brown	1

	Ft.
Cornbrash	
? Lagenalis Zone. Clay, brown, marly	1
Limestone, rubbly	4
Clay	½
Limestone, rubbly	3
Limestone, in several courses, massive, blue-hearted ...	2½
Wychwood Beds	
Clay, with 'scab rock', 1 in. thick, flooring the bottom ...	6

No section has been observed in the Langley, Leafield, Ramsden or Wilcote outliers, but a boring made for the improvement of the water-supply at The Hayes on the Ramsden outlier was carried to a depth of 360 ft. (at which depth it was stopped in the Capricornus Beds) and proved (Pringle 1926, p. 17):— Gravel, 6 ft.; Oxford Clay and ? Kellaways Beds, 21 ft.; Cornbrash, 11 ft.; Forest Marble [? nearly all Kemble Beds], 25 ft.; Great Oolite Series, 142 ft.; Inferior Oolite, 27 ft,; Upper, Middle and Lower Lias, 128 ft.

Horton (1860, p. 251) records the *Kamptokephalites herveyi* (J. Sowerby), an ammonite indicative of Upper Cornbrash, from a quarry, now lost sight of, beside the road between Witney and Long Hanborough.

The bottom part of the Cornbrash is exposed in the old and the new East End Quarries, North Leigh (p. 56).

In the Swan Inn Quarry, Long Hanborough, the whole of the Cornbrash, 8 ft. 6 in. thick, is visible.

Swan Inn Quarry, Long Hanborough

	Ft.	In.
Pleistocene		
River gravel of the Hanborough Terrace	6	0
Kellaways Beds		
Clay, blue: 8 in. to	2	0
Upper Cornbrash		
Lagenalis Zone. Clay, ironshot, marly, shaly towards the base; *Microthyris lagenalis* (Schlotheim), *Rhynchonelloidea cerealis* S. Buckman (rare), *Pholadomya sp.*, *Camptonectes laminatus* (J. Sowerby), *Modiola sp.*, *Dolikephalites dolius* S. Buckman (*vide* J. Pringle)	0	4
Siddingtonensis Zone. Limestone, hard, brown, with eroded upper surface; *Microthyris siddingtonensis* (Walker), *Rhynchonelloidea cerealis* S. Buckman (common), *Trigonia scarburgensis* Lycett, *Lopha marshii* (J. Sowerby), *Homoeoplanulites sp. indet.* (cf. *subbakeriae*, A. d'Orbigny)	0	8
Lower Cornbrash		
Obovata Zone. *Astarte-Trigonia* Bed. Limestone, shelly, becoming rubbly below; *Trigonia sp.*, *Entolium demissum* (Morris and Lycett *non* Phillips), *Modiola sowerbyana* d'Orbigny, *Pseudomonotis echinata* (Smith), *Kallirhynchia* cf. *yaxleyensis* (Davidson) (near base), *Clydoniceras sp.* (Second *Clydoniceras* Bed of Dr. J. Pringle)...	4	6
Clay, blue, with branching, sandy, calcareous concretions; *Ornithella obovata* (J. Sowerby), *O. grandobovata* S. Buckman	1	0
Intermedia Zone. Limestone, tough, rubbly; abundant *Cererithyris intermedia* (J. Sowerby), *Clydoniceras*. (First *Clydoniceras* Bed of Dr. J, Pringle) ...	2	0
Wychwood Beds (*see* p. 57)	3	5
Kemble Beds (*see* p. 57): seen to	5	6

Douglas and Arkell, who described this section (1928, pp. 129, 130; Arkell 1933, p. 182) remark: " The chief features of interest are:— The presence of '*intermedia*' zone resting directly on Forest Marble, and underlying '*grandobovata*' beds: the occurrence of the *Astarte-Trigonia* horizon at the top of the Lower Cornbrash: the rarity of *Kallirhynchia* of the *yaxleyensis* group; the occurrence of a thin but typical representative of the "*siddingtonensis*" zone (mentioned by Mr. Buckman as 'massive Stalbridgian limestones of Hanborough, Oxon'); and the remnant of the '*lagenalis*' zone ".

The Obovata (part of) and Intermedia zones are exposed in the Hanborough Station Quarry (p. 62) and old Spinney Quarry, Bladon (p. 63).

In a disused quarry near Campsfield Farm, half a mile west-north-west of Kidlington Station, the normal sequence is seen:— a remnant of the Siddingtonensis Zone, typical *Astarte-Trigonia* Bed, rubbly beds full of *Ornithella obovata* which at Kidlington yield large specimens of *Ornithella grandobovata* and, at the base, a band crowded with *Cererithyris intermedia* (*see* Douglas and Arkell 1928, p. 130).

Near the Campsfield Farm, 1⅖ mile east of Woodstock Church, is a small quarry in which Lower Cornbrash is seen with sandy marl, 8 in. thick representing the Intermedia Zone, crowded with *Cererithyris intermedia*, at the base. This rests on clay (1 ft.) and limestone, belonging to the Wychwood Beds.

Woodward (1894, p. 447) examined the new cuttings of the Woodstock Branch Railway in 1889 and found the Cornbrash to be from 12 to 14 ft. thick. At the top he noted 3 ft. 8 in. of limestone beds containing specimens of '*Waldheimia*' *lagenalis* and '*Rhynchonella varians*' (=*Rhynchonelloidea cerealis* S. Buckman). Beneath these limestones, it is clear from Woodward's account that the sequence is similar to that in the quarry near Campsfield Farm to the north-west of Kidlington Station:—" The basement-bed [2 ft.] crowded with fine specimens of *Terebratula intermedia* was the most noticeable feature . . ."

On the east side of the Cherwell valley there are sections of the Cornbrash in the Upper Greenhill Quarry, near Bletchingdon Station and at the top of the Kirtlington Cement Works (abandoned) quarry.

Upper Greenhill Quarry, Bletchingdon

	Ft.	In.
? Kellaways Beds ('much disturbed and not in situ')		
Sand and soil, with quartzite and other pebbles of the superficial deposits	3	0
Clay, blue, with irregular masses of sand ...	3	0
Red ochreous layer, probably in situ	0	1
Upper Cornbrash		
1. Marl, brown, 6 in. to	0	9
2. Oyster Bed; many *Lopha marshii* (J. Sowerby) with *L. undosa* Phillips and *Camptonectes lens* (J. Sowerby)	0	1
3. Limestone, hard, nodular, purplish, dark-blue centred, apparently much decalcified, with well-preserved shiny pink, or orange-coloured fossils; a Macrocephalitid ammonite (fragments), *Microthyris siddingtonensis* (Walker), *M. sublagenalis* (Davidson), *Ornithella stiltonensis* (Walker), *Dictyothyris elegans* Douglas and Arkell *Rhynchonelloidea inflata* Douglas and Arkell, *R. cerealis* S. Buckman, *Pleurotomaria buchiana* d'Orbigny and other gastropods, *Lopha marshii* (J. Sowerby) and other lamellibranchs, *Serpulae*: 6 in. to	0	8

Lower Cornbrash	Ft.	In.
4. *Astarte-Trigonia* Bed. Limestone, platy; *Trigonia angulata* J. de C. Sowerby, *T. rolandi* Cross, *Astarte hilpertonensis* Lycett, *Chomatoseris porpites* (Smith), *Entolium demissum* (Morris and Lycett *non* Phillips) *Pygurus michelini* Cotteau, etc.	3	0
5. Limestone, rubbly; *Pseudomonotis echinata* (W. Smith), *Limatula helvetica* Oppel, *Pholadomya detoidea* J. Sowerby, *Ornithella obovata* (J. Sowerby), *Cererithyris intermedia* (J. Sowerby), and *Clydoniceras sp.*	2	3
6. Limestone, compact; *Pseudomonotis echinata* very abundant and *Ornithella obovata* ...	1	9
7. Marly, parting; *Ornithella obovata, Homomya gibbosa* (J. Sowerby)	0	6
8. Limestone, compact; *Trigonia angulata* J. de C. Sowerby, *Astarte hilpertonensis* Lycett. At the base is a layer containing abundant *Clydoniceras*	1	6
9. Limestone, rubbly, mottled, argillaceous, with pockets of *Ornithella obovata* and *O.* cf. *magnobovata* S. Buckman in abundance, also large specimens of *Nautilus truncatus* J. Sowerby	0	4
Wychwood Beds (*see* p. 67): 0 to	1	3
Kemble Beds (*see* p. 67)	11	0

Arkell and Douglas (1935, pp. 320, 321) draw attention to the richness of the brachiopod fauna of bed 3; the occurrence side by side in the same bed (bed 3) of *Microthyris siddingtonensis* and *M. sublagenalis* (which they had previously concluded could be regarded as alternative zonal indices); and an abnormality in the faunal sequence of the Lower Cornbrash, namely, the absence of the Intermedia Zone from the base, but the occurrence of the characteristic brachiopod higher up between strata containing the Astarte-Trigonia fauna and belonging to the Obovata Zone (Douglas and Arkell 1928 p. 131; 1932, pp. 123, 144).

The Cornbrash at the top of the Kirtlington Cement Works quarry (Sheet 218) has a nodule-bed at the base, which "attracts attention as a possible remainé pebble-bed," and resembles that in the Upper Greenhill Quarry in lacking the Intermedia Zone at the base, but having the characteristic brachiopod of that zone higher up—in the upper of two *Astarte-Trigonia* beds in the Obovata Zone. The section, (as noted by Douglas and Arkell (1932, p. 124) is as follows:—

Cement Works, Kirtlington

Lower Cornbrash	Ft.	In.
1. Limestone, rubbly and marly; *Pseudomonotis echinata* (Smith) *Entolium demissum* (Morris and Lycett *non* Phillips), *Pleuromya decurtata* (Phillips), *Homomya gibbosa* (J. Sowerby), *Trigonia rolandi* Cross, *Astarte hilpertonensis* Lycett, *Nucleolites clunicularis* (Smith), *Cererithyris intermedia* (J. Sowerby), and *Ornithella obovata* (J. Sowerby)	3	6
2. Limestone, tough, *Pseudomonotis echinata* (Smith)	2	6
3. Marl and rubbly limestone, in places nodular; casts of *Pleuromya decurtata* (Phill.) abundant	0	9

4. *Astarte-Trigonia* Bed. Limestone, very hard, grey; crowded with *Trigonia rolandi, T. angulata, Astarte hilpertonensis, Entolium demissum,* and *Ornithella obovata*; also *Trigonia griesbachi* Lycett, *Trichites reticulatus* Rollier, etc.	2	0
5. Clay, brown, marly, with *Ornithella obovata,* and many fragments of oysters and *Pseudomonotis echinata* (Smith). In this band are nodular lumps of tough grey limestone containing *Pleuromya decurtata*	1	0
Wychwood Beds (*see* p. 69)		
Kemble Beds (*see* p. 69)		
White Limestone (*see* p. 70).		

The Cornbrash was formerly well exposed in the railway-cutting at Kidlington Station (Phillips 1860, p. 117) and in a quarry about halfway between the station and the village (Woodward 1894, p. 448). Whiteaves (1861, pp. 106, 107) made a large collection of fossils from this neighbourhood, but he included the Bradford Fossil Bed of Islip in the Cornbrash (Blake 1905, p. 13).

Cornbrash, Wychwood Beds and Great Oolite emerge through the Oxford Clay to form an inlier at Islip. According to Pringle (1926, p. 25): " The general structure is that of an anticlinal dome dislocated by faults, but the complication of detail is too great to be determined with exactitude by such field-evidence as is available at present. The railway-cutting, though much overgrown shows all the strata involved in the anticline " (*see* Fig. 2).

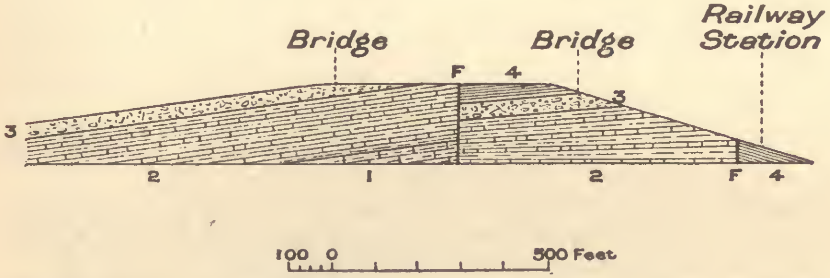

FIG. 2.—*Section of Islip Railway-cutting.* 4.—Oxford Clay. 2.—Forest Marble. 3.—Cornbrash. 1.—Great Oolite. F.—Faults.

Islip Quarry

	Ft.	In.
Lower Cornbrash :—		
1. Limestone, compact; *Cererithyris intermedia* (J. Sowerby), *Pseudomonotis echinata,* etc. ...	1	0
2. Marly rubble	0	4
3. Limestone, rubbly; *Ornithella obovata* common; also *Entolium demissum, Chlamys vagans, Pseudomonotis echinata, Limatula cerealis, Pleuromya decurtata, Pygurus michelini,* etc. ...	2	0
4. Clay, brown, marly; *Ornithella obovata* ...	0	3
5. Limestone, rubbly, fossiliferous; *Cererithyris intermedia* and *Ornithella obovata* (both rare), and many other fossils as in limestone above the clay	0	3
Wychwood Beds (*see* p. 71)	5	0
Kemble Beds (*see* p. 72): seen for	5	0

Douglas and Arkell, who described the section, (1932, p. 124) remark that the Cornbrash sequence here is very similar to that at Kirtlington, " the repetition of *Cererithyis intermedia* in the upper beds being again noticeable." Pringle (1926, p. 26) records *Clydoniceras discus* (J. Sowerby) from his First Clydoniceras Bed (bed 3 above) and *Clydoniceras hochstetteri* (Oppel) from his Second *Clydoniceras* Bed (bed 1 above).

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CHAPTER VII

OXFORD CLAY AND KELLAWAYS BEDS

By W. J. Arkell

THE Oxford Clay and Kellaways Beds occupy nearly half the area under consideration; but owing to the Thames gravels and alluvium that cover the greater part of the outcrop, and to the scarcity of exposures, they are still imperfectly known, even though this area is the type district of the Oxford Clay.

The country is for the most part flat or only gently undulating. From the Thames valley there is a gradual rise, up the dip-slope, northward to the margin of the Cornbrash, and a steep ascent southwards to the escarpment of the overlying Corallian Beds. Here and there the base makes a minor escarpment facing north over the Cornbrash country, as, for example, about Curbridge and from High Coggs and Coggs Wood to Church Hanborough and Bladon Heath. This may be partly due to the shaly and slightly more resistant quality of the lower beds of the Oxford Clay, but may also be attributed to a hard development of Kellaways Rock, which, though not very thick, is enough to check erosion to a greater extent than the soft clays above and below (*Cf.* the little escarpment of the thin Arngrove Stone south-east of Ot Moor). These formations, so far as they can be seen, are much the same in the present area as along the rest of their outcrop from Dorset to the Humber. They comprise the following zones (*see* Arkell 1933, pp. 340, 341, Pls. xxxvi-xxxvii; 1936, pp. 175-182; 1939, pp. 207-214). The total thickness is about 450 ft.

	Zones	Lithologic Character
Oxford Clay	*Cardioceras cordatum* (= *cardia*)	Clay with ammonites chiefly as pyritic or limonitic casts
	Quenstedtoceras mariae and *Creniceras renggeri*	
	Quenstedtoceras lamberti	
	Peltoceras athleta	
	Erymnoceras coronatum	Shaly clays with compressed Kosmocerates
	Kosmoceras jason	
Kellaways Beds	*Sigaloceras calloviense*	Sand and sandy limestone
	Proplanulites koenigi	Clay

Details

The Cordatum (=Cardia) Zone, previously called, erroneously, the Precordatus or Praecordatum Zone, is well exposed at Studley Brickyard, five miles east of the map margin, where it abounds in limonitic casts of *Cardioceras costellatum* S. Buckman, *C. costicardia* S. Buckman, *C. quadrarium* S. Buckman, and other allied forms. Some layers are crowded with large specimens of *Gryphaea dilatata* J. Sowerby (including *G. controversa* Roemer, *G. discoidea* Seeley sp., *G. exaltata* Rollier) (Arkell 1932, pp. 160-170). An exposure at New Marston Brickyard, on the eastern margin of the sheet, between Marston village and Magdalen Bridge, is now overgrown.

In spite of the scarcity of permanent exposures, the Cordatum Zone is well known around Oxford by reason of its characteristic *Gryphaea* shells, which are dug out in abundance whenever excavations are made. During the extensive growth of the suburbs around Wolvercot, Headington, and New Marston between 1930 and 1934, large quantities of these shells were dug up; but ammonites are comparatively rare. Sections were then to be seen in a deep sewer trench down the hill between the end of Pullen's Lane and Old Marston, and in a cutting for the Oxford Northern By-pass Road between Old Marston and the River Cherwell. Many of the streams and the larger ditches descending from the Corallian escarpment also show the characteristic oysters, and they are dredged from the bed of the Thames between Bablock Hythe and Tadpole Bridge, in some places direct from their parent clay and in others, as derived specimens, from the river gravels and alluvium. An exposure of clay with *Gryphaea* can be seen in the river bank a short distance below Northmoor lock. Excavations for the Bodleian Library in Broad Street, Oxford, 1937, exposed, beneath the gravel, up to 6½ ft. of Oxford Clay belonging to the Lamberti Zone. From the tipped clay were collected about 240 small ammonites, many belemnites and lamellibranchs, some crushed Collyritidae, and crab's claws, *Goniocheirus cristatus* Carter (Arkell 1938, p. 1). The Mariae Zone was proved at Botley Pound, near the foot of Cumnor Hill, in a sewer trench along the Eynsham road. *Cardioceras scarburgense* (Young and Bird) was collected here.

The section in the brickyard at Wolvercot shows the Athleta Zone (*see* Pringle 1926, p. 36; Arkell 1939, p. 207).

Wolvercot Brickyard

		Ft.	In.
	Pleistocene gravel		
Athleta Zone	6. Clay, lead-coloured with *Kosmoceras proniae* Teisseyre and allied forms, *Peltoceras subtense* (Bean) in upper part and *P. athletoides* Lahusen at base	16	0
	5. Cementstone, pale, impersistent. Many fossils : *Kosmoceras proniae* etc., *P.* cf. *subtense* etc.	1	6
	4. Clay, lead-coloured : *K. proniae*	2	6
	3. Clay, as above : *P. athleta* (Phillips) etc. ...	2	6
	2. Cementstone, pale, variable thickness. Upper surface often encrusted with shells preserved in pyrites. *Aulacothyris bernardina* (d'Orbigny), *Rhynchonella spathica* (Lamarck), *Gryphaea lituola* Lamarck, etc.		6
	1. Clay, as above : *Kosmoceras duncani*. Seen to	4	0

The commonest fossils obtained in this pit, from the clays of both zones, are the shells of an oyster, *Gryphaea lituola* Lamarck, a species recorded in the Oxford Memoir (Pringle 1926, p. 170) as *G. bilobata*; the guards of the belemnite *Cylindroteuthis puzosi* (d'Orbigny) (="*Belemnites owenii*" Pratt) (Lissajous 1925, p. 116); and fine-ribbed Kosmocerates of the type *K. proniae* Teisseyre. Owing to the abundance of the last, Pringle suggested making a separate zone of *K. proniae;* but the species ranges up through, and is only a subsidiary or alternative index fossil for, the Athleta Zone (Brinkmann 1929, p. 56). The same applies to *K. duncani* (*see* Arkell 1939).

Clays on approximately the same level along the Northern By-pass between Wolvercot tunnel and the canal, and at the City of Oxford waterworks (1932-3) on Wytham Hill were unfossiliferous.

A better exposure than that at Wolvercot, seen in the Summertown brickyard, is now occupied partly by the Morris Radiator Co.'s works. The pit was 40 ft. deep, and from the large numbers of fossils, now in collections throughout the country, it appears to have shown the Athleta, Lamberti and Mariae Zones. As Pringle remarked (1926, p. 37), the zonal succession here has a tectonic interest: "The occurrence of these zones at Summertown pit proves that the south-easterly dip of the formation has been modified by the Islip disturbance, the effects of which are also to be seen in the structure of the Corallian rocks in Wytham and Seacourt Hills to the west."

The lower zones of the Oxford Clay (the old Zone of *A. ornatus*), and the Kellaways Beds, although they undoubtedly pass across the district and floor a considerable area, are known only from wells, borings and chance exposures. Records of fossils collected from these zones in recent years at Freeland and near Kidlington are noted by Pringle (1926, p. 35), but the ammonites were recorded before the publication of Brinkmann's revision of the nomenclature.

During the making of the Woodstock Branch Railway a cutting at Shipton on Cherwell showed 5 ft. of sands overlying 10 ft. of clay, resting on the Cornbrash, and these strata were attributed to the Kellaways Beds (Woodward 1895, p. 40). In an exposure at the same horizon at Greenhill near Enslow Bridge, the clay and sand above the Cornbrash proved to be disturbed (Douglas and Arkell 1935, p. 319).

Between Witney and Shore's Green, the widening of the main road, in 1933, exposed unfossiliferous yellow clay and clayey sand, which probably belong to the Kellaways Beds.

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CHAPTER VIII

CORALLIAN BEDS

By W. J. Arkell

THE Corallian Beds in the south-east corner of the district form part of the classic area surrounding Oxford. Since the time of Buckland and J. Sowerby they have received the attention of many observers, and were known to be rich in fossils even in the days of Lhuyd.

The beds fall into two divisions, the Lower Corallian being represented by the Lower Calcareous Grit, while the Upper Corallian comprises the Berkshire Oolite Series and the Osmington Oolite Series.

The Berkshire Oolite Series, in the present district a thin group of sands and clays associated with the Shell-cum-Pebble Bed, forms the basal beds of the Upper Corallian. The succeeding Osmington Oolite Series consists of Coral Rag, Wheatley Limestones and Littlemore Clays, three deposits which may replace one another either vertically or laterally.

On the map the Shell-cum-Pebble Bed is included, as a rule, in the Upper Corallian, but farther west, and locally near Oxford, it occurs within the area shown as Lower Calcareous Grit.

LOWER CALCAREOUS GRIT

The Lower Calcareous Grit consists of yellow and white, false-bedded, calcareous sands with, here and there, bands of large spheroidal concretionary masses or doggers. The false-bedding continues into the doggers. Generally the sand contains numerous small pebbles of black lydite and white vein quartz, of unknown origin, though presumably derived from Palaeozoic rocks. The thickness of the grit varies greatly even in the small area included in the present district. Wells around Chawley and Cumnor prove up to 50 ft., and the same thickness has been found at Littlemore, just off the south-eastern margin of Sheet 236; whereas at the Abingdon waterworks at Wootton cross-roads only 11ft. of sands and sandstone or ' gritstone ' separate Coral Rag from the Oxford Clay which was penetrated to 34 ft. The usual thickness is about 30-40 ft., as in the new Abingdon waterworks half a mile south-east of Bessels Leigh Church.

Fossils are, as a rule, rather scarce in the Lower Calcareous Grit, except in the Natica Band, which is well exposed at Cumnor and in the quarries around Dry Sandford and Marcham (Sheet 253). The commonest are *Natica arguta* Phillips, *Nautili* and *Aspidoceras catena* (J. de C. Sowerby) with the shells dissolved away, sometimes leaving intricate internal casts of the chambers linked loosely together, or replaced by crystalline calcite. Silicified wood is also common.

Berkshire Oolite Series

The Lower Calcareous Grit is overlain by a deposit known as the Shell-cum-Pebble Bed which is typically developed over the plateau at Headington east of Oxford (Sheet 237). In the present area it is only to be seen in its typical development in a quarry at the electricity station a quarter of a mile south-west of North Hinksey Church. It consists of a tough grey limestone with large shells, and pebbles of lydite and vein quartz, pebbles of the gritstone itself, and of phosphatic mudstone probably derived from concretions in the Lower Calcareous Grit. Other pebbles are of more distant origin, one composed of soda rhyolite having been found at Kingston Bagpuize, two miles beyond the southern margin of the area (Arkell 1931*a*, p. 51). The bed is rich in lamellibranchs and large ammonites, chiefly of the genus *Perisphinctes.* They include especially the subgenera *Perisphinctes sensu stricto*, *Arisphinctes*, *Kranaosphinctes* and *Dichotomosphinctes*, represented by numerous species. Besides these, *Cardioceras excavatum* (J. Sowerby), *C.* (*Goliathiceras*) aff. *goliathum* (d'Orbigny) and *C.* (*Vertebriceras*) *vertebrale* (J. Sowerby) occur (*see* Arkell 1936; 1938). The lamellibranchs, often perfectly preserved, belong to the genera *Trigonia*, *Lima*, *Camptonectes*, *Chlamys*, *Gervillia*, *Ostrea*, *Oxytoma*, *Isognomon*, *Astarte*, *Isocyprina*, *Cucullaea* etc.

Around Oxford and in the districts to the south and west, the Shell-cum-Pebble Bed is interbedded with and overlain by clays and sands through which the fauna of the Shell-cum-Pebble Bed ranges. These beds, about 6 ft. thick, constitute the Berkshire Oolite Series, which increases in thickness westward through Berkshire and Wiltshire, attaining a maximum of 30 ft. at Highworth, Wiltshire.

Osmington Oolite Series

The Osmington Oolite Series is of interest, owing to the luxuriant growth of corals, from which the formation received its first name, Coral Rag. It is well exposed in the district in all its varied facies. Over most of the plateau surrounding Cumnor, Chawley and Boars Hill, and again on the summit of Wytham Hill, quarries and temporary excavations reveal typical rag, identical with the rubbly ragstone so named by William Smith in Wiltshire. Reef-building corals compose the rock up to a thickness of 20-30 ft., the massive varieties *Isastraea explanata*

(Goldfuss) and *Thamnasteria concinna* (Goldfuss) sometimes forming irregular blocks a yard or more in diameter. The whole is knit together by the ramifications of the dendroid varieties *Thecosmilia annularis* (Fleming) and, especially at Cumnor and Wytham, *Rhabdophyllia phillipsi* Edwards and *Cladophyllia conybeari* Edwards. These last two corals are usually much less common than the others.

Typical Coral Rag contains a large proportion of clay, in which are numerous fragments of shells—mainly of *Exogyra nana* (J. Sowerby) and spines of echinoderms. Occasionally tests of the latter are found, most commonly of *Cidaris* (*Paracidaris*) *florigemma* Phillips. In addition an assemblage of lamellibranchs and gastropods, belonging to a limited number of species, are always found among the coral reefs but are either absent or rare elsewhere. These are:—*Chlamys nattheimensis* (de Loriol), *Lima* (*Plagiostoma*) *zonata* Arkell, *Lopha gregarea* (J. Sowerby), *Lithophaga inclusa* (Phillips) and *Littorina muricata* (J. Sowerby) (*see* Arkell 1928, pp. 143-149). The Lithophagas have riddled the corals, attacking especially the dead under sides. Sometimes oysters attached to pieces of coral are partly covered by later coral skeleton.

Fossil coral reefs are well displayed in cuttings and an old quarry alongside the Oxford road at the summit of Cumnor Hill; again a mile farther along the same road at Bradley Farm Quarry, and in an old pit on the east side of Wytham Hill, in Wytham Great Wood.

Other quarries, however, such as those at Sunningwell ("The Quarrey"), Wootton (Amey's Corner, 300 yds. S.S.W. of Manor Farm), Cumnor Hill (on the opposite side of the road to the rag quarry), and Wytham Hill (summit), show an entirely different type of rock. The rag is here replaced by greyish-white limestones, called Wheatley Limestones from their thick development at Wheatley, and by softer beds or 'brash.' Both the limestones and the brash are built up of finely ground shell and coral fragments, with scattered ooliths and often a good deal of tufaceous material. Recognizable fossils are rare, though here and there thin bands of coral occur, as in a quarry on Cumnor Hill, on the south side of the main road at the summit, while 80 yds. away a cutting for a house entrance displays one of the best sections of reef corals in Berkshire. Since both exposures are on the same level, the quarry 7 ft. and the cutting 10 ft. deep, and the stratification is virtually horizontal, the two types of deposit must pass into one another laterally.

The lateral passage of the detrital Wheatley Limestone type into Coral Rag can be seen in a single quarry face at Bradley Farm Quarry, Comnor (*see* p. 89).— On the other hand, a pit half a mile south-west of South Hinksey (p. 97), Coral Rag overlies Wheatley Limestones, while in another pit, half a mile south-west of North Hinksey (p. 97), and in wells west of Amey's Corner, Wootton (p. 95), Wheatley Limestones overlie Coral Rag. The two types of rock are interchangeable both vertically and horizontally in short distances.

In the south-east corner of the district the rag beds pass laterally into clays and thin bands of mudstone, with large masses of *Serpulae* and *Exogyrae*. These, the Littlemore Clay Beds, are well seen in a quarry in Bagley Wood and still better in Littlemore railway-cutting south-east of Iffley Church.

The Coral Rag, Wheatley Limestones and Littlemore Clay Beds are, on stratigraphical and palaeontological grounds, correlated with the Osmington Oolite Series of Dorset. The series is 60 ft. thick on the Dorset coast, but in Wilts., Berks. and Oxon. it does not exceed 30 ft. The higher Corallian Beds of Dorset are absent around Oxford where the Rasenia Zones of the Lower Kimmeridge Clay rest directly upon an eroded surface of the Osmington Oolite Series. The correlations are explained by the following table:

Ammonite Zones	Dorset Strata	Dorset Divisions	Divisions near Oxford	Divisions north-east of Wheatley
Ringsteadia pseudocordata	Ringstead Coral Bed Ringstead Waxy Clay Sandsfoot Grit	Upper Calcareous Grit	Absent	Ampthill Clay
Perisphinctes variocostatus	Sandsfoot Clay *Trigonia clavellata*-Beds	Glos Oolite Series		
Perisphinctes plicatilis	Osmington Oolite & Littlemore Clay Beds facies.	Osmington Oolite Series	Coral Rag & Wheatley Lsts. & Littlemore Clay Beds facies	Oakley Beds or *Exogyra-nana* Beds Arngrove Stone
	Bencliff Grit Nothe Clay *Trigonia hudlestoni*-Bed	Berkshire Oolite Series	Shell-cum-Pebble Bed, or *Trigonia* Beds	
Aspidoceras catena	Nothe Grit	Lower Calcareous Grit	Lower Calcareous Grit	Absent

Details.

Lower Calcareous Grit and Berkshire Oolite Series.—The most instructive section in the present area is that at Bradley Farm, Cumnor (see Blake and Hudleston 1877, p. 307; Pringle 1926 p. 49; Arkell 1927, p. 77).

Bradley Farm (Rockley) Quarry, Cumnor

	Ft.	In.
Osmington Oolite Series		
9. Coral Rag: Typical, with fine reef corals *in situ*; *Thecosmilia, Thamnasteria, Isastraea* and *Cladophyllia*, with *Exogyra nana* (J. Sowerby), *Lithophaga inclusa* (Phillips), *Lopha gregarea* (J. Sowerby), *Plicatula weymouthiana* Damon, *Chlamys nattheimensis* (de Loriol), *Lima zonata* Arkell, *Littorina muricata* (J. Sowerby), *Cidaris florigemma* Phillips, *Serpulae* ... ... 0 to	4	0
On the east side of the quarry this rests directly on Bed 6, but in the north-east corner it passes laterally into Beds 7 and 8 and spreads out over them.		
8. Brash, consisting of loose, finely ground-up shells and corals; non-oolitic; few recognizable fossils other than *Exogyra nana* ... 0 to	2	0
7. Consolidated brash, forming a hard white limestone ... ... 0 to	1	0
Berkshire Oolite Series		
6. Upper Trigonia Bed: Yellowish limestone with pebbles at the base; packed with shells, especially *Astarte ovata* W. Smith, *Gervillia aviculoides* (J. Sowerby), *Isognomon subplana* (Etallon), *Trigonia hudlestoni* Lycett, *T. reticulata* Agassiz, *Chlamys splendens* (Dollfus), *C. fibrosa* (J. Sowerby), *Cucullaea contracta* Phillips, *Lima rigida* (J. Sowerby), *Exogyra nana* (J. Sowerby), *Natica* (*Ampullina*) *arguta* Phillips, *Pleurotomaria*.	1	10
Three inches above the base this bed yielded (June 1933) two specimens of *Cardioceras sowerbyi* Arkell (= *C. cordatum* J. Sowerby *pars*).		
5. Interlaminated sand and clay, with small pebbles of quartz and lydite. *Cardioceras sp. nov.* and *C. cordatum* (*fide* Blake and Hudleston) in nodules, which also contain nests of *Cylindrites polygyrus* 2½ft. to	5	6
(Position of the Lower Trigonia Bed of Marcham)		
Lower Calcareous Grit:—		
4, 3, 2. The Natica Band: In three parts, irregularly bounded:		
4. Intensely hard calcareous grit with lydites, and a few mudstone 'pebbles' appearing on the weathered top surface; locally a mass of gastropods.		

		Ft.	In.
3.	Porous mass of gastropod casts; inconstant. *Natica (Ampullina) arguta* Phillips, *N. (A.) clio* d'Orbigny, "*Natica*" *felina* Blake and Hudleston, *Cloughtonia condensata* (d'Orbigny), *Cylindrites polygyrus* Phillips, *Ceritella costata* Whiteaves, *Pseudomelania heddingtonensis* (J. Sowerby), *Pleurotomaria reticulata* J. Sowerby, *Pl. bicarinata* Sowerby, and *Nerinea goodhallii* Sowerby.		
2.	Intensely hard calcareous grit, with lydites. All three parts together up to	6	0
2*a*.	Pseudoconglomerate of irregularly rounded and tubular grey mudstone bodies, which look like pebbles in cross-section but are not bored or encrusted and are undoubtedly of different origin	0 to	3
1.	Yellow sand, false-bedded, with some seams of clay towards the top. Small pebbles of lydite and quartz	9	0

The correlation of the Bradley Farm Quarry with the Marcham quarries (Sheet 253), and the position of the Natica Band in relation to other exposures, is proved by pits opened since 1932 at Dry Sandford and Cothill, just off the southern margin of the district. These show the Natica Band with the pseudo-conglomerate at the base and underlying both the Trigonia Beds of Marcham. The Lower Trigonia Bed contains rolled and bored and encrusted pebbles at Marcham and elsewhere, and is separated from the Upper Trigonia Bed by interlaminated sand and clay like Bed 5 of Bradley Farm Quarry. The Lower Trigonia Bed is absent not only from this section, but also from the northern end of Sheepstead Farm Quarry, Marcham (*see* Blake and Hudleston 1877, p. 306; Arkell 1927, p. 92). The thickness of the Natica Band given by Blake and Hudleston is undoubtedly a misprint for "8 to 10 ft."

The type specimens of *Perisphinctes plicatilis* (J. Sowerby) and *Cardioceras vertebrale* (J. Sowerby) came from a "sandy stratum containing beds of sandy limestone at Dry Sandford and Marcham" (Sowerby 1817, Pls. clxiv, clxv), which form part of the Berkshire Oolite Series (*see* Healey 1904, pp. 55, 56, pl. ix).

If the specimen of *Trigonia hudlestoni* Lycett figured (1872, p. 27, pl. vi, fig. 1) as from the Lower Calcareous Grit of Cumnor in Lycett's monograph (wrongly identified as *T. triquetra* von Seebach), came from Cumnor, it was presumably from Bed 6 of the Bradley Farm Quarry.

A few feet of sands and shelly gritstones of the Berkshire Oolite Series can still be seen in an old flooded quarry immediately south of Bradley Farm. A small quarry 300 yds. N.E. of Cumnor Church is worked in shelly pisolite resting on yellow sands.

Quarrying at Bessels Leigh in the Lower Calcareous Grit or the Berkshire Oolite Series in the seventeenth century is indicated by many records of fossils by Lhuyd (1699) as coming "Ex lapicidina Basisleiana'. The exact site is not known, but there is an overgrown shallow pit on the north side of the main road a quarter of a mile north-east of the church, and depressions on the south side of Lashford Lane, 450 yds. east of the Greyhound Inn. The species figured by Lhuyd from Bessels Leigh are those now known as *Natica (Ampullina) arguta* Phillips (= *N. marchamensis* Blake and Hudleston) and *Pseudomelania heddingtonensis* (J. Sowerby); (Lhuyd 1699, Nos. 322, 341, Tab. 7). *Lithophaga inclusa* (Phillips) is also mentioned as from "Basie's-Leigh" and "Ivy-Hinxey" (Lhuyd 1699, p. 42, Nos. 879, 880).

Old quarries on the east bank of the brook, half a mile south-east of Great Park Farm, worked the shelly calcareous gritstones and sands

Borings for Abingdon Corporation at Lashford Lane

North-West

Boring No. 4

	Ft.	In.
Soil	1	0
White sand	3	0
Rock	15	0
Yellow sand	2	0
Rock		4
Yellow sand	5	8
Rock		6
Green sand	2	0
Rock		3
Green sand	2	3
Sandy clay	7	0
Rock		3
Sandy clay	9	9
Rock	1	0
Sandy clay	—	—
Total	50	0

Boring No. 3

	Ft.	In.
Soil	2	0
Sandy "Rag"	4	0
Stone	3	0
Yellow sand	14	0
Blue rock	2	0
Green sand	3	0
Rock	1	0
Sand	1	0
Rock		6
Sand	1	6
Rock	1	0
Sand		9
Rock		6
Sand		9
Rock		6
Sandy clay	8	6
Rock		3
Sandy clay	5	9
Total	50	0

Boring No. 2

	Ft.	In.
Soil	1	0
Sandy "Rag"	5	0
Sand and rubble	11	0
"Corallian Grit"	5	0
Boulder rock	1	0
"Corallian Grit"	5	0
Rock	1	3
Sand		6
Rock		6
Sand		9
Rock		9
Sand	1	0
Rock		3
Sand	1	6
Rock		6
Sandy clay	15	0
Total	50	0

South-East

Boring No. 1

	Ft.	In
Soil.	1	10
Sand	1	8
Rock	8	0
Yellow sand	7	0
Blue clay and sand	14	0
Rock		6
Sand	1	6
Rock		9
Sand		9
Rock		9
Sand		6
Rock		6
Clay		6
Rock		9
Clay	—	
Total	39	0

of the Berkshire Oolite Series, now so well exposed in the large new quarries near Bradley Farm. Similar stone, but always with a predominance of sand, is ploughed up on the hill west of the brook, and again east of Rockley Copse, Bessels Leigh.

The four new borings and wells for the water supply of Abingdon (1929-30), half a mile south-west by west from Wootton Church, proved the strata shown in the table on page 91. The information was supplied by Mr. W. H. Lewis, Borough Engineer.

From the positions of the borings, close to the outcrop of the Coral Rag, it is almost certain that they passed through the Berkshire Oolite Series. Unfortunately the cores were destroyed, and it is not known whether the Natica Band and Pebble Bed were present, or what thickness should be ascribed to the Berkshire Oolites. The " sandy rag " almost certainly does not indicate Coral Rag; nor does " Corallian Grit," which probably means partially hardened sand. The interest of the borings lies in the evidence they afford of the variability of the Lower Calcareous Grit; sands, sandstones (' gritstones '), and sandy clays alternate both vertically and horizontally in very short distances.

Here, the lowest 15-20 ft. consist of sandy clay with thin bands of rock. Near Cumnor a thick, dark grey to almost black clay occurs in the middle part of the Lower Calcareous Grit. When freshly dug it looks as heavy as Oxford Clay, but when dry is seen to be more or less sandy. It gives rise to a plateau midway between that of the Upper Corallian and the floor of the Thames valley. Good exposures of the clay, devoid of fossils, were seen in 1934 in roadside trenches from 3 ft. to 4 ft. deep, dug for water mains through Cumnor. From surface indications it appears that the clay extends southwards for about a mile along the brook and may cause the marsh at Bessels Leigh.

Early in 1934 a well dug on the north side of the road at Manor Farm, Eaton, passed through 32 ft. of grey sandy clay and 6 in. of grey sandstone, weathering friable and full of stick-like or ' fucoidal ' markings. No fossils were found, but the rocks closely resembled the grey Nothe Grits at Osmington Cascade in Dorset.

Osmington Oolite Series.—An excellent temporary exposure of Coral Rag was available in 1933, in a trench from the Abingdon Corporation borings (*see* p. 91) to the reservoir, half a mile south-east of Wootton Church. The trench was 2 ft. wide and a mile in length. In traversing the high ground between Bradley Wood and Berrymere Copse it reached a depth of 15 ft., and for a third of a mile a depth of over 10 ft. For the rest of the distance it varied from 5 ft. to 3 ft. deep, ending in the reservoir excavation with a depth of 20 ft.

For the first few yards after leaving the topsoil at well-head, yellow sand was excavated at the bottom. At the base of the bed of Coral Rag was a hard limestone with many large lamellibranchs and some pebbles; but many crystalline lumps of coral occurred right down to the contact with the sand. The hard limestone probably represented the Upper Trigonia Bed at Bradley Farm (Bed 6, p. 89). Thence upward to the top, and throughout the whole of the rest of the trench, nothing was excavated but Coral Rag with a variable proportion of hard white detrital or Wheatley Limestone bands.

After following Sandford Lane due south to the first bend, the trench struck east-south-east across the fields. For about half a mile from the well-head, where the trench was deepest, luxuriant Coral Rag was encountered, largely composed of well-preserved corals with clay in the interstices. Abundant fine specimens of *Isastraea, Thamnasteria, Thecosmilia, Cladophyllia* and *Rhabdophyllia* were present, associated with a typical coral-dwelling fauna (see p. 87).

The trench on the west side of Berrymere Copse was from 3 ft. to 5 ft. deep. A marked change was observed, rag with clayey interstices abruptly giving place laterally to flaggy white limestone (Wheatley Limestone facies, similar to that exposed in an old quarry 200 yds. to the north-east) which extended for rather less than 200 yds.; fine rag, with many massive corals, then came in again before the southern extremity of Berrymere Copse was reached. From this point the trench continued north of east to the main road, re-entering Wheatley Limestones in the eastern half.

The excavation for the reservoir, close to the old wells at the cross roads, showed a 20-ft. section, all except the top 2 ft. consisting of Coral Rag with a few thin lenticular hard bands. Even the hard bands were riddled with calcitic corals, especially *Thecosmilia annularis.* The greater part of the rag was of loose rubbly type with much clayey interstitial matter and some large masses of *Isastraea* and *Thamnasteria.*

The modern works nowhere reached the bottom of the rag, but the old wells, made about 1877, passed through the whole of the Corallian Beds into the Oxford Clay. The section (Woodward 1895, p. 125; Blake 1902, p. 102) was as follows:—

Abingdon Waterworks, south-east of Wootton

		Ft.	In.
Coral Rag	Ragstone	31	6
Lower Calcareous Grit	Solid blue stone	2	6
	Clean sand	6	0
	Solid blue stone	2	6
Oxford Clay	Soft soapy clay	34	6

This record gives the greatest proved thickness of Coral Rag known in the district. It is only exceeded elsewhere in England at North Grimston in Yorkshire and in some of the borings in Kent. Half a mile to the north-west the thickness is 6 ft. less, and the rag has passed almost entirely into the Wheatley Limestone facies. A well made recently near Wootton Church passed through the following:—

Well near Wootton Church

		Ft.	In.
Kimmeridge Clay	Clay	9	0
Coral Rag (probably Wheatley Limestone facies)	Rock	24	6
Lower Calcareous Grit	Sand, with plenty of water	8	0

The Wheatley Limestones and detrital brash facies are well seen in three quarries near Manor Farm, Wootton. One, long disused, 300 yds. S.S.W. of the farm, on the west side of the main road, shows 15 ft. of irregularly-bedded alternating bands of whitish detrital material, mainly composed of comminuted shells and echinoderms and finely-ground coral and tufaceous matter of a mealy appearance. Recognizable corals are rare, though *Cladophyllia* and *Thecosmilia* occur. The section is strongly reminiscent of those at the Wheatley and Lye Hill quarries. That the material was ground down elsewhere, and drifted into its present position, though probably from no great distance, is shown by the occurrence in one of the softer bands of a large *Trichites,* with the two valves still united. Such a very large fragile shell could not have survived any comminuting process, or have travelled more than a very short distance after the death of the mollusc.

A second quarry, at the limekiln in the nearby road-fork, Amey's Corner, and a third quarry, 200 yds. farther west, exposed about 8-12 ft. of Wheatley Limestones with some bands full of branching corals. The contrast between the rock here and the loose clayey rag on the same stratigraphical horizon in the pipe-trench only 500 ft. away, was most striking.

The writer has mapped the area between Cumnor and Wootton, on the 6-inch scale, and has traced the boundaries of the Coral Rag. Although there is evidence suggesting that Coral Rag passes vertically into the Wheatley Limestones, and although around Wootton the latter form higher ground

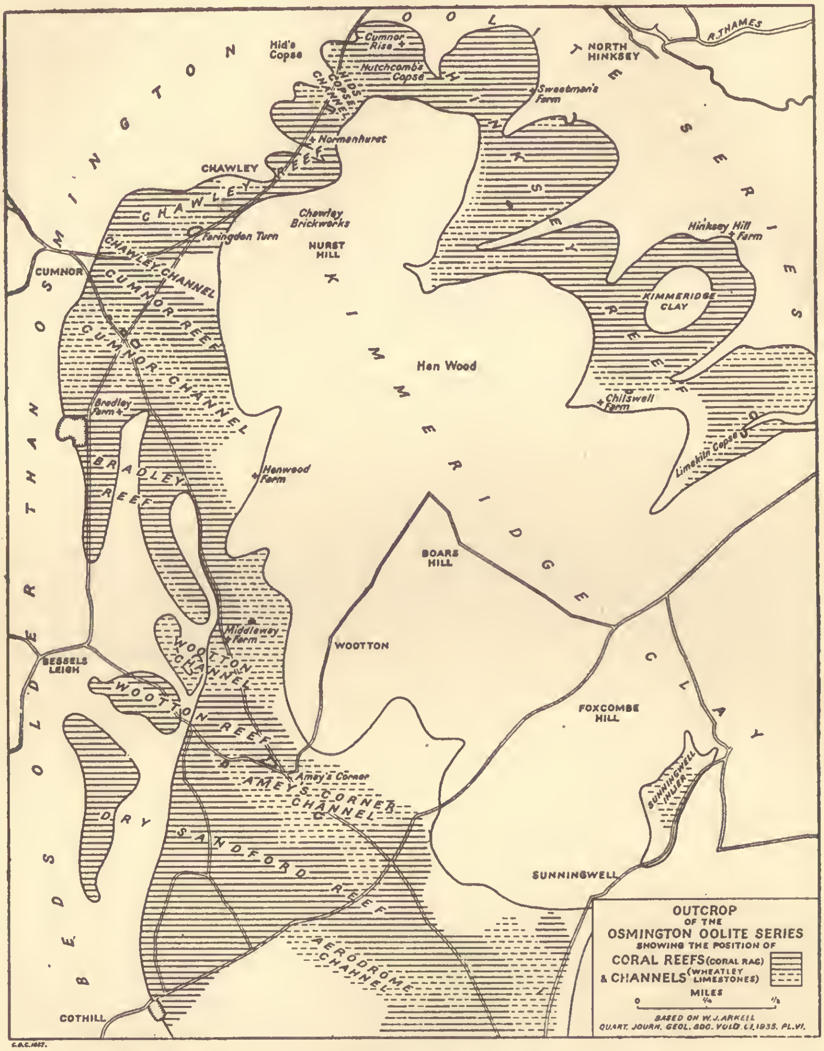

FIG. 3.—*Sketch map of the outcrop of the Osmington Oolite Series around Cumnor.*

(Outliers of Lower Greensand etc. on the Kimmeridge Clay have been omitted).

and adjoin the Kimmeridge Clay tract, yet it appears that the passage from the one type of rock to the other is generally a lateral one. Consequently it is justifiable to regard the apparent boundaries of true Coral Rag as approximately marking the original outlines of the patches of coral reef (*see* Arkell 1935, pp. 77-110). The results of the mapping are reproduced in Fig. 3. The boundary of the "Upper Corallian," as drawn on Old Series Geological Sheet 13, 1863, and reproduced with little alteration on the Oxford Special Sheet of 1908 also required revision. The Berkshire Oolite Series in this area is too sandy to map separately from the Lower Calcareous Grit, the only possible line to follow being the lower boundary of the Osmington Oolite Series or Coral Rag and Wheatley Limestones.

The following exposures are dealt with in order from south to north :—

The Quarry, Sunningwell

	Ft.	In.
Osmington Oolite Series.		
3. Hard whitish platy Wheatley Limestone with some corals	3	0
2. Brashy, soft, broken-shell rock, with some oolitic and pisolitic grains, spines of *Cidaris florigemma*, and a few corals	3	6
1. Similar rock but harder (Wheatley Limestone) with spines of *Cidaris smithi* Wright and fragments of *Isastraea*	3	0

As remarked by Pringle (1926, p. 49), the corals here do not seem to have grown *in situ*. Kimmeridge Clay follows almost immediately above.

Close to Wootton Church at the road-fork the following section was exposed until recently :—

Amey's Corner Limekiln Quarry

	Ft.
3. Hard, grey, flaggy limestone, with irregular bands of soft brash as below. Abundant *Exogyra nana* ; also *Thecosmilia annularis* (Fleming), *Chlamys nattheimensis* (de Loriol), *C. qualicosta* (Etallon), *Plicatula weymouthiana* Damon, *Velata anglica* Arkell, *Pseudomelania heddingtonensis* (J. Sowerby). Passing laterally to the west into typical Coral Rag (mainly *Thamnasteria concinna* Goldfuss *sp.*) ... up to	4½
2. Soft, cream-coloured, broken-shell brash, well bedded, resembling compressed sawdust 2 ft. to	4
1. Hard greyish white limestone as at Wheatley, separated by partings of soft brash like bed 2, Numerous *Exogyra nana* and *Cidaris* spines ; ramifying cavities mark dissolved *Thecosmilia annularis*	4

This quarry has yielded a specimen of *Chlamys qualicosta* (Etallon) a Pecten characteristic of the Osmington Oolite Series of Dorset and not known to occur at a lower horizon (*see* Arkell 1931*b*, p. 112).

A 6-ft. quarry 300 yds. due west of Amey's Corner shows similar beds, the lowest being hard limestone like Dagham Stone of the Great Oolite, with branching cavities which bear impressions of *Thecosmilae*, also numerous spines of *Cidaris* and unbroken shells such as *Cucullaea* and *Velata*.

Farther west, a well for new houses showed 5 ft. of Wheatley Limestones overlying 4 ft. of rag. The rag comes to the surface in the fields immediately north of the houses, swings round the valley separating the two quarries and eastwards along the road to Oxford for 300 yds. from Amey's Corner. A well at Jack's Piece Nursery yielded some of the largest masses of *Thamnasteria concinna* (Goldfuss) in the district. They are preserved in the rockery. Rag also occupies all the tract of country around Dry Sandford and the two outliers west of Sandford Brook.

About 600 yds. from Amey's Corner along the Oxford road, on the east side, wells at a row of houses showed typical Wheatley Limestones, with no corals, to 12 ft. Two old quarries 300 yds. N.W. and 450 yds. N.N.W. of Middleway Farm worked the same rock, and it was proved in a pipe-trench to extend to the dip in the road just north of the farm. Within 300 yds N. of the farm, along the road, however, a series of wells and cess-pits showed rag to a depth of 12 ft. Here there is an unrivalled luxuriance of *Isastraea* *explanata* (Goldfuss); and the corals can be easily traced in the fields northwards (there is an old pit north-east of Henwood Cottages) to Bradley Farm, on the sides of the Oxford road and along both the southerly spurs.

North of the reef about Bradley Farm runs the Cumnor Channel, an elongate tract of Wheatley Limestones. In the old deep quarry in the north quadrant of Cumnor cross-roads, described by Blake and Hudleston (1877, p. 308), bedded Wheatley Limestones and rubbly brash extend for 13 ft. down to the sands and are stratified to the base. Similar rock is exposed in old excavations along the road south-eastwards, towards Henwood Farm.

Parallel with this channel runs a strip of rag, indicated by the abundant corals on the fields. This is the Cumnor Reef. It is separated from the Chawley Reef to the north by the Chawley Channel which runs north-west by west and is exposed in an old roadside pit and is traceable by surface indications and a well at the new houses at the east end of Cumnor.

The old quarry at the Faringdon Turn, half a mile south-west of Chawley, shows Wheatley Limestones, as did also the trench beside the main road at this point, dug in 1934-5 for bringing water mains to Cumnor, but this area is entirely surrounded by the rag of the Chawley Reef. Besides being conspicuous on the open plateau north of the Oxford-Cumnor road, the coral rock, composed of large heads of *Thamnasteria concinna* with subordinate *Isastraea, Thecosmilia* and *Rhabdophyllia,* was penetrated in the wells of all the houses built during 1931-4 on both sides of the road between Chawley Brickworks and Cumnor, and also by the pipe trench along the main road.

North-east of the entrance to Chawley Brickworks there have been of late years many exposures of Coral Rag along both sides of the Oxford road. Between the fork where Hurst Lane leads off to the Kennels and the first dip in the main road, hard rag is overlain by a few feet of brash and that in turn by a 2-ft. band of exceptionally hard white limestone rich in *Rhabdophyllia phillipsi* Edwards.

Probably the best exposure in the district is displayed to a depth of 10 ft. in the entrance-drive to Normanhurst, Cumnor Hill. Masses, up to 5 ft. in diameter, of saccharoidal corals (*Thamnasteria concinna* (Goldfuss) and *Isastraea explanata* (Goldfuss)) stand in position of growth in an unbedded amorphous matrix of clay and rubble, full of the reef-dwelling molluscs and branching corals (*Thecosmilia annularis* (Fleming)). The section provides an excellent opportunity for studying a reef *in situ.* On the opposite side of the road a quarry showed about 12 ft. of similar unbedded rag, though there the individual heads of coral were smaller. A sunk road to a building estate, known as Cotswold Road, 80 yds. N.E. of the entrance to Normanhurst, formerly showed 7 ft. of white Wheatley Limestones in typical hard and soft beds, without a trace of coral rock. A band one foot thick contains prostrate corals, mainly *Thecosmiliae,* but otherwise it is difficult to believe that the section is so close to the unbedded reef mass at Normanhurst. Yet the two exposures are on the same level and the strata are horizontal.

New houses and the water-pipe trench beside Hids Copse Road also showed Wheatley Limestone. Farther north-east, extensive excavations for the house and rock garden of Mr. Tipping showed mainly very hard and massive Wheatley Limestones, with some large lumps of coral. An older rockery at Larkbeare, higher up the hill, shows a similar mixture. These two sites stand close to the edge of the Hinksey Reef; in fact, the Hinksey and Chawley reefs are probably confluent under Chawley Hurst.

The Hinksey Reef has been well exposed in recent years owing to the opening up of the Harcourt and other building estates. It is first seen at Cumnor Rise (new wing built in 1933) and the adjacent houses, and may be traced round the head of the coombe at Hutchcomb's Copse, where fine examples of *Cladophyllia conybeari* Edwards may be found. It was continuously exposed from the junction with the Lower Calcareous Grit almost up to the Kimmeridge Clay by pipe-trenches up Yarnell's Road and by

Sweetman's Farm to the water-tower at the head of the coombe above North Hinksey. Excavations in 1934 for a house immediately north of the water tower, showed luxuriant rag separated from Lower Calcareous Grit by a very shelly Shell-cum-Pebble Bed, crowded with *Gervillia aviculoides* (J. Sowerby), *Astarte ovata* (W. Smith), *Chlamys fibrosa* (J. Sowerby), *Isognomon subplana* (Etallon), *Velata anglica* (Arkell), etc.

The old quarry in which the electricity station now stands, by the road south-west of North Hinksey, has been described elsewhere (Arkell 1927, p. 144). There have been numerous exposures all over the plateau to the south of this, on both sides of the two coombes above the old rifle range, as far as Hinksey Hill Farm and Chilswell Farm. The most important were in the excavations for the power-line pylons, and for the pipe-line carrying water to Boars Hill, by way of Hen Wood (*for details see* Arkell 1935). All showed typical Coral Rag, except at the head of the coombe immediately north of Hen Wood, where there is a thick lenticle of Wheatley Limestones with Coral Rag above and below.

South of the Chilswell Farm valley there is obviously a vertical sequence; the rag becomes confined to the top of the plateau, whereas round the edge and in the valleys Wheatley Limestones crop out. Nodular rubble of the Wheatley Limestones is quarried to a depth of 7 ft. in the field east of the farm. An old quarry in the north side of the valley 600 yds. E.N.E. of the farm shows the highest 2 ft. of the Wheatley Limestone facies, overlain by 7 ft. of Coral Rag.

The next valley to the south shows the relations still better. In the north side a large old quarry 150 yds. N.E. of the east end of Limekiln Copse shows 10 ft. of Coral Rag overlying 6 ft. of Wheatley Limestones, and a smaller quarry 150 yds. farther east shows 8 ft. of the latter. On the opposite side of the valley, there are three quarries showing the same rocks. One of them shows 6 ft. of Coral Rag overlying 5 ft. of bedded coralline rubble alternating with bands of hard Wheatley Limestone.

South of the Hinksey Hill road, in the south-eastern corner of the map, the Corallian Beds crop out along the lower slope of Bagley Wood. There was formerly a quarry at Kennington, close to the church, which showed the Shell-cum-Pebble Bed and yielded some fine lamellibranchs and ammonites (Arkell 1927, p. 90). Some Littlemore Clay Beds can still be seen at the top. Only one quarry is now open in the higher beds, in Bagley Wood, and here they have passed into the argillaceous facies known as Littlemore Clay Beds described below:—

Bagley Wood Quarry (1926)

	Ft.	In.
Littlemore Clay Beds		
Five or six bands of grey clay and greyish-white argillaceous, nodular, limestone or mudstone	4	0
Alternating bands of clay and nodular mudstone ...	4	4
Blackish clay		4 to 6
Whitish mudstone as above, breaking up irregularly...	1	1
Grey-brown clay		3
Whitish mudstone as above, breaking up irregularly with marl	1	6
Marly clay		3
Nodular mudstone, as above, many ill-preserved fossils, mainly *Exogyra nana*; also *Astarte ovata* W. Smith, *Trigonia hudlestoni* Lycett (both rare), *Ampullina clio* (d'Orbigny), *Pseudomelania heddingtonensis* (J. Sowerby), *Isognomon sp.*, *Isocyprina cyreniformis* (Buvignier), *Pholadomya hemicardia* Roemer, *Pleuromya*, *Cidaris* spines, *Holectypus corallinus* d'Orbigny		3 to 5

	Ft.	In.
Marly, pellety clay; many *Exogyra nana* and some of the other fossils in the bed above ... ... 1 to		3
Berkshire Oolite Series		
Very hard dark grey shelly limestone	1	3
Marly sand		

Some of the fauna of the lowest mudstone in the Littlemore Clay Beds occurs also scattered through the higher bands. From a fallen nodule the writer collected a test of *Holectypus corallinus* d'Orbigny, apparently the only one recorded in Britain.

The type-section of these clayey beds is in Littlemore railway-cutting, on the eastern margin of the district, half a mile south-east of Iffley Church (*see* Buckman 1925, pp. 61, 62; Sollas 1926, p. 69, fig. 18; Pringle 1926, p. 52; Arkell 1927, p. 142, fig. 14; 1933, p. 407, fig. 71), and is almost identical with that just described in Bagley Wood; in addition the downward continuation through the Berkshire Oolite Series and into the Lower Calcareous Grit is well displayed. The old Bagley Wood quarry was formerly worked much deeper, presumably to procure the limestones of the Berkshire Oolites as seen at Littlemore, but the lower part is now hidden by scree, and the lowest bed seen probably represents Bed 7 at Littlemore.

The Corallian rocks on Wytham Hill are a continuation of those on the main outcrop, but they are separated by a fault or a sharp syncline, and are themselves anticlinal in structure, lying, as Pocock pointed out (1908, pp. 31, 32), on the prolongation of the Islip Anticline. Ancient quarries cover an extensive area on the summit, near the chalet, having probably supplied road metal for the old coach road that passed over both Wytham Hill and Seacourt Hill to the south-east. These quarries expose Wheatley Limestones. On the descent towards Wytham village, however, smaller pits, some of them worked more recently, display typical Coral Rag. In one of them *Rhabdophyllia phillipsi* is abundant. Luxuriant rag also litters the arable fields around the south-eastern slope of Wytham Hill and over a large part of Seacourt Hill is obscured by drift.

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CHAPTER IX

KIMMERIDGE CLAY

By W. J. Arkell

THE Kimmeridge Clay enters the area of the map for a distance of three miles in the ridge of Boars Hill and Bagley Wood, terminating northward near Cumnor and Chawley. The only villages on the outcrop are Wootton and Sunningwell, and they are close to the junction with the Corallian Beds, into which their wells penetrate.

The total thickness of the clay on Boars Hill is only about 90 ft. This is due partly to piecemeal attenuation of the component zones and partly to removal of the upper zones before the deposition of the Lower Greensand. The zones and strata represented are shown in the table on the opposite page.

Details

The only exposure of the Kimmeridge Clay in the area is the famous Chawley Brickyard, on the north slope of Hurst Hill. Here the Zone of *Aulacostephanus pseudomutabilis*—partly exposed and highly fossiliferous—is seen to be overlain by clays with richly fossiliferous nodules belonging to the Virgatosphinctoides (Subplanites?) Zones. These are overlain, in the present face of the pit, by the Lower Greensand, which is in turn cut into by a channel filled with Gault clay and Pleistocene gravels. Formerly there was some evidence of the Pectinatus Zone, but it has not been recognized in recent years.

The clays of the Pseudomutabilis Zone were long ago renowned for their saurian remains, and fragments of large bones and vertebrae can still be collected. From this pit, of which a section follows, came the type specimen of *Camptosaurus prestwichi* (Hulke) (Prestwich 1879, p. 193; 1880, p. 430; Hulke 1880, p. 433; Seeley 1888, p. 698), and in addition *Ichthyosaurus, Plesiosaurus, Pliosaurus,* and *Dacosaurus* are represented.

Section at Chawley Brickworks

		Ft.
Drift	Bedded gravel of quartzite, flint, etc., with sand ...	10
Lower Gault	Clay, dark bluish-grey, with phosphatic nodules and fragments of *Hoplites dentatus* (J. Sowerby). A sandy basement bed is sometimes exposed : up to	10
Lower Greensand	Sand, coarse, quartzose, with concretionary ironstone ; more false-bedded and flaggy towards top	20

Zones	Dorset Coast	Cumnor
Pavlovia spp.	Clays on Hounstout, Rotunda Nodules and Crushed Ammonoid Shales	Absent
Pectinatites pectinatus	Clays in Egmont Bay	Not now seen, but occasionally encountered as Shotover Grit Sands facies. The zone is represented by ammonites; specimens are preserved in Oxford University Museum, from Chawley.
Virgatosphinctoides and *Subplanites*	Clays of Rope Lake Head and Clavell's Hard. Blackstone, etc.	Clays with numerous ammonites.
Gravesia spp.	Clays in Hen Cliff below Yellow Ledge	Absent
Aulacostephanus pseudomutabilis	Clays of Kimmeridge Bay and Broad Bench with *Exogyra virgula* and Saurian bones	Clays with *Exogyra virgula* and Saurian bones
Rasenia spp.	Clays with *Ostrea delta* at Ringstead and Weymouth	Thin, not seen
Pictonia baylei	Clay with *Rhactorhynchia inconstans* at base	Absent, or represented by seam with *Rh. inconstans*

		Ft.
Kimmeridge Clay	Clay, grey, sandy, with yellow seams, weathering light to a depth of 3 ft., with a few grey nodules which weather brown ... ... about	14
	Shaly clay, darker than above, with large cementstones, often septarian, which contain *Lucina minuscula* Blake, *Modiola autissiodorensis* (Cotteau), *Virgatosphinctoides*; in some places a mass of ammonites	8
	Clay, dark, with *Exogyra virgula* (Defrance), *Aptychus latus*, *Aulacostephanus eudoxus* (d'Orbigny) and reptilian bones. At the top is a seam of brownish clay with *Exogyra virgula*	10

The section was described by Pringle (1926, p. 68) who stated, " In 1924, the junction of the Pseudomutabilis Zone with the overlying clays was exposed on the north side of the pit, but a few feet to the south the Virgula Beds are thrown down by a fault, and are not again exposed. The floor of the pit is occupied by dark shaly clays with cementstones."

Many years ago the Kimmeridge Clay was also exposed beneath the Lower Greensand on the west side of Foxcombe Hill, but the pits have long been overgrown. Recently clay has been seen lying directly on Wheatley Limestones, with an abrupt junction, in some of the holes for electricity pylons at either end of the valley between Hen Wood and Hurst Hill. No fossils were found in the clay, however, and it is not certain that it represented the base of the Kimmeridgian *in situ*.

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CHAPTER X

LOWER GREENSAND AND GAULT

By W. J. Arkell

SANDS referred to the Lower Greensand cap the ridge of Boars Hill, Pickett's Heath and Foxcombe Hill, and the smaller outliers of Hurst Hill and the hill south-west of North Hinksey. The maximum thickness is shown by wells in certain parts of the main Boars Hill ridge to be about 50 ft.

The formation consists of very coarse quartz sand, false-bedded and impregnated with iron, which locally cements it into hard layers or forms concretionary ironstone nodules or box-stones. The grains of sand are commonly from 1 to 3 mm. in diameter and are well rounded. Locally, towards the base, they become especially coarse and give place to lenticular patches of well-rounded quartz pebbles up to three-quarters of an inch in diameter. No fossils have been found.

At Chawley Brickworks (p. 100) about 20 ft. of the sands are exposed. They are seen to rest unconformably on the Kimmeridge Clay, not on the top of the formation, but on the Virgatosphinctoides and locally on the Pectinatus Zones. Hence, before the Lower Greensand was deposited, the Pavlovia Zones (Swindon Clay), the greater part of the Pectinatus Zone (Shotover Grit Sands), and the Portland and Purbeck Beds which are present on Shotover Hill, had been eroded away. This important fact, combined with the absence of freshwater fossils, which are found in the ferruginous sands overlying the Purbeck Beds on Shotover, and the well-rounded and large quartz grains and pebbles, suggest comparison with the transgressive marine Lower Greensand of other localities rather than with the estuarine beds of Shotover and Brill. If the sands were of Wealden age they would probably have rested with apparent conformity on the Purbeck Beds; if they are Lower Greensand, however, they would be expected to lie discordantly on older members of the Jurassic System, having been deposited during a period of widespread marine transgression.

The only occurrence of Gault is the small outlier on Boars Hill. This is masked by superficial deposits except for two small tongues cropping out from beneath the drift west of Pickett's Heath Farm.

Details

The best section is at Chawley Brickworks, Hurst Hill, where the uneven junction with the Kimmeridge Clay is seen. The Lower Greensand is in turn cut into almost down to the base by a Pleistocene channel, which looks, in cross-section, like a river valley. The channel must have been cut at a time when Gault succeeded the Greensand either here or in the close vicinity. for the base and sides are filled not only with Pleistocene drift but also with Lower Gault clay yielding *Hoplites dentatus* (J. Sowerby) (Sollas and Healey 1905, p. 57).

The lowest 15 ft. of the Lower Greensand is mainly even-bedded though much disturbed by slipping on the side of the hill. There is a rough alternation of soft and harder irony bands, and small pebbles are common. In the highest 5 ft. the strata are more flaggy and false-bedded. The false dip is about 20° south-west.

Another fine section, 12 ft. deep, was made in 1932 to obtain material for building Jarn Mound, on the summit of Boars Hill, north-east of the old village. The excavation has been left open on the north-east side of the mound. The lowest 6 ft. seem to be an upward continuation of the top beds at Chawley, for the sands are flaggy and partly indurated, and are strongly false-bedded with a false-dip of 25 or 30°. The tops of the inclined beds are abruptly truncated by flatter-lying beds along a conspicuous line about the middle of the pit face; but locally there is false-bedding in the upper 6 ft. also, with a false-dip in the same direction as in the lower part. The harder bands of ferruginous sandstone have been used in the rockeries of the Sir Arthur Evans public wild garden near by. From one to three feet of pebbly Unbedded Drift rests upon a very irregular surface of the Lower Greensand.

Another channel or depression similar to that on Hurst Hill may occur here, for on a slightly lower level a few yards to the south, five or six feet of (?)Gault clay used to be dug, with only local admixture of pebbly drift. The old pit is now converted into an ornamental lake, but clay may still be seen in the banks. In 1934 a new cemented tank was made near by, and the excavation for this revealed nearly pure clay.

Similar sands, varying from yellow to red in colour, may be seen at several points on the ridge: especially in the road-cutting and adjoining entrances near the Boars Hill Hotel (on Foxcombe Hill), in small pits by the roadside on Tommy's Heath, and in a small pit, 6 ft. deep, east of the track from Pickett's Heath to Chawley, in the east end of Hen Wood.

The Gault of Boars Hill is not often exposed, but a well at the north end of the hill proved dark blue clay, probably of this formation (Pringle 1926, p. 103).

References for Chapter X.

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CHAPTER XI

PLEISTOCENE AND RECENT DEPOSITS

By H. G. Dines

THE superficial deposits of the area include Glacial and post-Glacial deposits. The former occur as patches distributed throughout a belt of country extending across the middle of the district from north-west to south-east. Post-Glacial deposits include river gravels and alluvium and are mainly confined to the valleys of the Thames and Cherwell, in the south and east of the area (*see* Fig. 4). Details given below of the Pleistocene deposits occurring within the area covered by the Special Oxford Sheet are taken from the accounts by Sandford (1926), and by Pocock (1908).

Glacial Deposits

The Glacial deposits comprise (1) Boulder Clay, (2) Glacial Sand and Gravel and (3) Unbedded Drift. The two former occur only on Lias of the Evenlode valley around Milton under Wychwood where they furnish the southerly extension of similar deposits in the Vale of Moreton (Sheet 217). Elsewhere glacial deposits are represented by Unbedded Drift, previously known as Plateau Drift.

In the Vale of Moreton the deposits contain chiefly Triassic quartzose pebbles and Chalk flints. From place to place one or the other of these predominates, a fact that indicates that confluent ice streams, from the north and north-east entered the vale from the north. Miss Tomlinson, however, (1929, pp. 157-196) separates the drift occurrences that carry mainly Triassic pebbles (Plateau Drift) from those carrying mainly flints (Moreton Drift) as being of different ages. She regards the former as older and classifies them with the deposits referred to in this memoir as Unbedded Drift.

It is a well-established fact that the Vale of Moreton was occupied by ice during the Glacial Period and that the higher portions of the ice must have, to some extent, overridden the Cotteswolds, leaving boulder clay that now persists only as traces preserved in crevices in the limestones (Lucy 1872, pp. 77-125; Callaway 1905, p. 217; Dines 1928, p. 70).

Since ice extended over the Cotteswolds, the main stream within the Vale of Moreton and the Evenlode valley must have

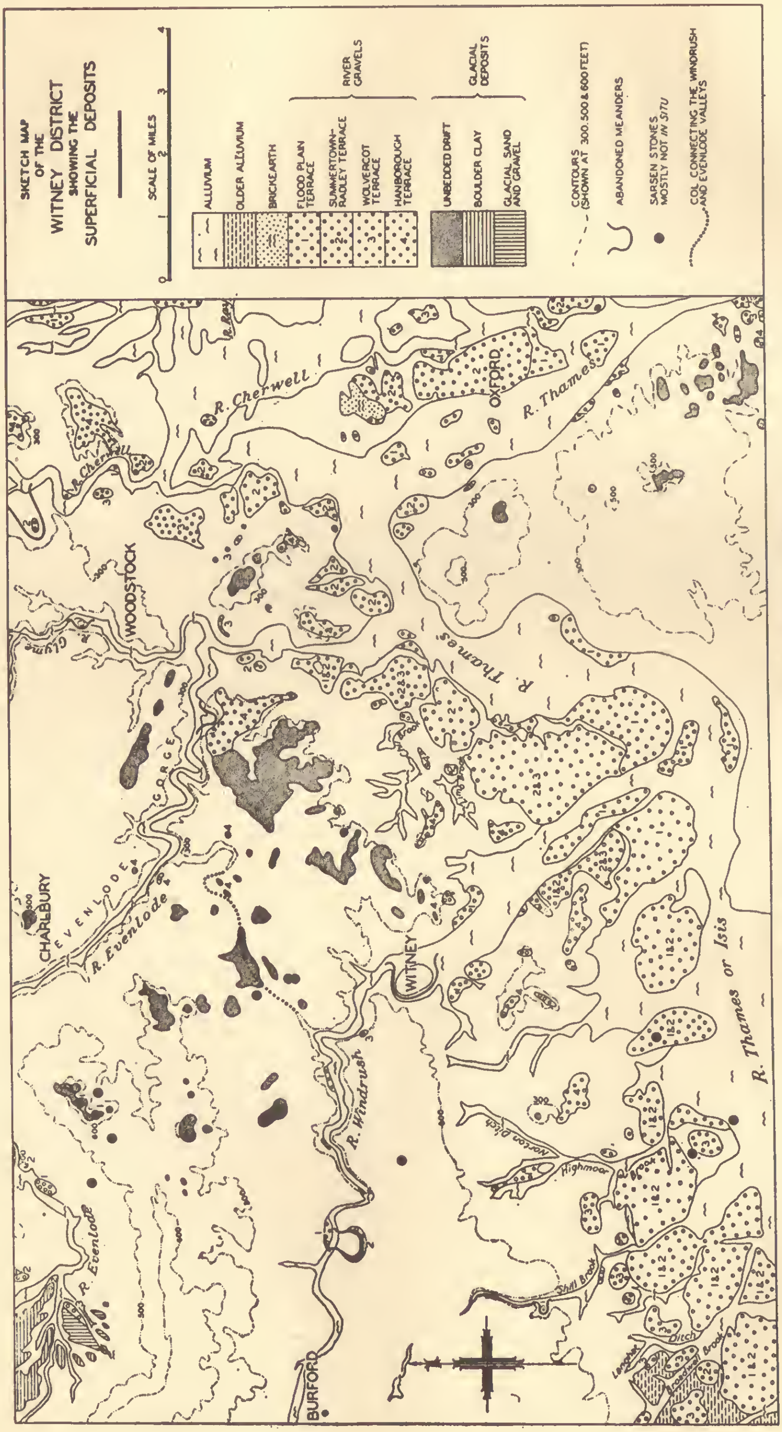


FIG. 4.—*Sketch-map of the Witney district.*

been of sufficient thickness to over-ride the ridge of Wychwood that forms the south bank of the Evenlode valley between Charlbury and Leafield, whence from the distribution of the Unbedded Drift, it appears to have taken a south-easterly course towards the Thames valley and the Goring Gap. The distribution of the drift is well shown in Buckland's maps of the Vale of the Evenlode and the Thames (1821, Pl. 37; 1823, Pl. 27).

On the retreat of the ice front, the tongue extending south-eastward from Wychwood was probably cut off from the main sheet and so became a stagnant mass of dead ice, melting in place and depositing its burden with little or no sorting, thus giving rise to the heterogeneous deposits of unbedded drift. On the other hand, the main mass of ice within the vale retreated depositing its load as till or ground moraine and gravel or outwash moraine.

Evidence of an ice-stream passing in a south-westerly direction along the Chiltern scarp slope and the Thame valley, and converging towards the south-easterly stream through Wychwood to meet it in the neighbourhood of the south-east corner of the area, is afforded by the presence of fresh unweathered Chalk flints in the Glacial deposits at Boars Hill.

There are no true glacial deposits within the Cherwell valley in the present area, but the river gravels contain a large proportion of northern pebbles which may have been derived from such deposits.

(1) BOULDER CLAY AND (2) GLACIAL SAND AND GRAVEL

Boulder clay forms the bulk of the superficial deposits on the Liassic outcrop in the north-west of the area. The matrix is a red-brown clay, stiff in places and sandy in others, heavily charged with pebbles of quartz and quartzite, some sub-angular flints and other derived stones. Associated with the boulder clay, and apparently underlying it, as in the Vale of Moreton, are a few spreads of Glacial sand and gravel consisting of orange to red-brown sand with a varying proportion of pebbles.

Details

The larger areas of boulder clay occupy flat ground at about 420 ft. O.D., comparable with the level of the boulder clay in the Vale of Moreton, but tongues and smaller patches lie at lower levels down to about 380 ft. There are no exposures in this area. The soil of arable land has a gravelly appearance, but the matrix is usually a heavy clay, which is red-brown in colour where unweathered. The Glacial sand and gravel is to be seen in a trench-like pit at the south-west end of Milton under Wychwood. The pit is mostly overgrown, but a fresh exposure at the end showed 6ft. of red sand with horizontal streaks of varying texture and shades of colour, suggestive of bedding, and a few scattered quartzose pebbles. Miss Tomlinson (1929, pp. 175, 176) noted in this pit 12 ft. of orange-red sand showing no stratification. There were a few lenticles of pebbles of quartzite and flint in the sand, and below, in the centre of the pit, about 6 ft. from the surface, a mass of rudely stratified angular oolite gravel with occasional quartzites and flint chips. Many flints, some white coated and fresh, occurred near the junction of the two deposits. A section in the same spread at Upper Milton, observed by Callaway (1905, p. 217) appears to show the relation of the Glacial Gravel to the Boulder Clay. He noted four feet of brown clay containing quartz pebbles and small angular flints, resting on 10 ft. of brown and grey interbedded sand, and he compared the clay with that of a small deposit of boulder clay at Tangley, a mile and a half to the west, on the Cotteswolds (*see also* Dines *in* Richardson 1933, p. 84). The boulder clay seen by Callaway is apparently of small extent and is not shown upon the geological map.

Smaller spreads of sand occur between Upper Milton and Shipton under Wychwood. In one of these, half a mile west of Shipton Court, there are two overgrown pits of which the larger still shows fine silty sand and pebbles. Another spread on the south side of the valley, half a mile south-west of Ascot under Wychwood has also been worked, and shows red or orange, coarse loamy sand with streaks of pebbles including quartzite, up to 6 ins. in diameter, and chips of flint.

According to Miss Tomlinson (1929, p. 166) the deposit here has been worked to a depth of 9 ft. but only shallow exposures are now visible. The sands east and north-east of Heath Farm are not exposed, but surface indications and augering show quartzose pebbles in a matrix of fairly coarse red-brown sand. The spreads of gravel and sand lie between 400 ft. and 360 ft. O.D.

(3) UNBEDDED DRIFT

Unbedded Drift consists of heterogeneous masses of red-brown clay, more or less sandy, with numerous quartzose pebbles and boulders. Flints are also present in various proportions and different states of weathering, and some rare pebbles of metamorphic and igneous rocks occur. Some of the stones show glacial striae.

The constituent pebbles of the deposits show that the ice that carried them into the district came from the north, while their distribution leaves little doubt that the bulk of the material entered by way of the Vale of Moreton and the Evenlode valley, though some may have come through the Cherwell valley, and some from the east through the Thame valley.

Unbedded Drift occurs in patches situated at all levels between 650 ft. and 300 ft. O.D. and appears to be the relic of a deposit that was spread over a pre-existing landscape in which the present river system had been developed, but had not yet cut the valleys below 300 ft. The general absence of structure or grading of the drift suggests deposition by decaying ice, though Sandford (1926, p. 106) puts this down to decalcification. The local resemblance to true boulder clay, as at Pickett's Heath (Sollas 1910, p. lviii; Sandford 1924, p. 121; 1926, p. 111), and to glacial sands with traces of bedding, as at Ramsden Heath, are characteristic of such deposits. Some of the patches appear to lie in a terrace-like arrangement at definite levels above the present streams. This is probably due to irregular dissection of the original deposit rather than to redistribution of the material by rivers (*but see* Pocock 1908, p. 104; Sandford 1926, pp. 114, 115; Overy 1923, p. 28), for all the spreads, even at the lower levels, retain their heterogeneous character.

The deposits, within the present district, are confined to a strip of country, about four miles wide, passing from Wychwood in a south-easterly direction through Boars Hill. Outside this belt, with the exception of the small patch at Lew, the only traces of glacial drift are scattered stones foreign to the district.

The erractics present in the Unbedded Drift have attracted the attention of several observers, and a list of the recorded finds is given by Sandford (1929, pp. 363-365) who classifies the pebbles as follows (1924, pp. 121, 122):—

(1) Flint (a) Nodular ochreous flint with deep white or brown patina, possibly from East Anglia; (b) grey-white nodular flint which resembles that of parts of East Anglia; (c) some nodules of fresh flint from the Chilterns.

(2) Quartzites and sandstones, supposedly from the Midlands.

(3) Tourmaline-grits and schorl-rock.

(4) Rare rocks, some of igneous origin.

Among the far-travelled rocks, specimens have been identified as being derived from Scandinavia, Scotland, East Anglia, the Midlands, Devon and Cornwall (Sandford 1929, p. 381). It is probable that those from the two last named counties, which consist of schorlaceous rocks some with cassiterite, were actually derived second hand from the Midlands via the Bunter Pebble Beds in which such rocks are known to occur (Matley 1914, pp. 211-215; Barrow 1919, p. 131; Jones 1923, p. 440).

In an endeavour to trace the source of such erratics, a number of pebbles from the drift of the Witney district were examined by Dr. J. Phemister, together with some of similar appearance from the Bunter Pebble Beds. Pebbles from both sources were submitted to Mr. E. H. Davison, who regards some of those which are tourmaline-bearing as definitely from the West of England. Details of the petrological descriptions are given below (p.).

Sandford, however (1929, pp. 378, 379), on the evidence then available, assumed a considerable submergence and suggested that the erratics were carried by detached bergs of shore- or river-ice from the south-west.

DETAILS

The highest spreads are those which cap the high ground separating the Evenlode and Windrush valleys at Wychwood, Leafield and Ramsden Heath. A pit, in intermittent use, about a quarter of a mile north of Stag's Plain, Wychwood Forest, is 5 ft. deep and shows 1½ ft. of grey-brown loamy clay with many pebbles pocketted to 2½ ft. in places into orange sandy clay with pebbles in bunches, surrounded by festoons of orange and grey clay with a few scattered pebbles. Quartzite and quartz pebbles are abundant; there are some ochreous flints, and chert and lydite are fairly common. The average diameter of the pebbles is 1½ ins., but some are 6 ins. across. Around this pit the soil appears to be sandy, but further west it is mainly a loamy clay. The moat at High Lodge is in grey and yellow clay mottled red, with many stones, which, in addition to Triassic pebbles, include some large grey patinated and some small ochreous flints.

The Leafield deposit is not well exposed but appears to be similar to that just described. It caps the high ground at over 600 ft. and trails off to lower levels southward. There are smaller patches around the main spread, and three very small occurrences at Langley. At Ramsden Heath, temporary pits north and south of the Leafield-Finstock road showed respectively stiff red and yellow clay, and grey and orange mottled coarse clayey sand. Both contained abundant pebbles. A little south of the road a pit exposes about 4½ ft. of orange and red sand, showing traces of bedding, and containing scattered stones (Richardson 1935, p. 406). Richardson has drawn the writer's attention to the similarity between the Unbedded Drift of Leafield and Ramsden Heath and the gravel and sand underlying chalky Boulder Clay around Brixworth, Northamptonshire.

From the Ramsden Heath spread a chain of patches extends southward to Hailey. Excepting the most southerly, these occur at successively lower levels, and the large patch upon which Gigley Farm is situated stands at 350 ft. O.D. This deposit occurs in an abandoned valley presumed to be a former course of the Windrush from Crawley to Ashford Mill (Bromehead 1909, pp. 141, 142). The southern slopes of this valley are capped by remnants, at about 400 ft. O.D., between Crawley and Hailey, east of Delly End and at New Yatt. A disused pit in the small patch west of Ramsden shows red-brown clay with pebbles, and a trench crossing part of the Gigley Farm patch exposed red-brown loamy clay with pebbles and boulders resting on an irregular surface of limestone.

North of Minster Lovell two fairly large spreads on the dip slope at about 430ft. O.D. were trenched to a depth of 4 ft., and showed the usual matrix and pebbles, some of which were large. The full thickness was not revealed. North of the mill at Minster Lovell, and to the west and east of Burycroft, near Crawley, traces of gravel are indicated by quartzose pebbles in the soil. These occurrences are not shown upon the map. They may either be remnants of spreads of unbedded drift, or of a river gravel terrace. To the west of Lew, a small patch of red and brown sandy loam with quartz and quartzite pebbles, and both ochreous and fresh flints, caps a small conical hill at about 340 ft. O.D. and some 50 ft. above the adjacent Hanborough Terrace river gravel.

On the north bank of the Evenlode, Unbedded Drift lies above the 500-ft. contour east of Charlbury, and caps a ridge extending from Notoaks Wood to East End. The pebbles here are frequently 8 ins. to 1 ft. across. A well dug just north of Combe showed 4 ft. of yellow clay with pebbles and boulders on Oxford Clay. At Combe brickyard, a mile east of the village, a section described by Sandford (1924, pp. 122, 123), is now largely overgrown.

At Wilcote and southwards between North Leigh and High Coggs, there are isolated patches, while around Freeland and the Demesnes there occurs the largest spread within the limits of the map. In this latter, north of Eynsham Hall Park, the surface, at 400 ft. O.D., stands some 200 ft. above the Evenlode, but it falls about 70 ft. towards Long Hanborough, to the level of the highest river terrace. The patches lying to the south also fall in level, and at High Coggs again almost reach the river terrace. Sections have been seen in these occurrences, one of the best being in the disused pits at Coombe and at the Demesnes. The deposit is an irregular bed of brown mottled loam, a few feet thick, full of stones set at all angles, penetrating the Oxford Clay in irregular hollows. The stones are a very mixed collection, among which occur numerous partially rounded flints a few inches across, and smaller fragments quite unworn. These were originally derived from the Chalk, but they are so deeply weathered that it is probable that they had gone through more than one stage of transport and deposit before reaching their present position. Other constituents are liver coloured quartzites, doubtless from the Bunter Pebble Beds of the Midlands, white vein-quartz and variously coloured quartzites, probably from the same formation, hard sandstones resembling greywethers, softer feldspathic sandstones of the Mill-stone Grit type, and black lydian stone of unknown origin. Pebbles of tourmalinized rock also occur. The deposits are unbedded, and well striated boulders are by no means rare, some examples being somewhat waterworn subsequent to their being scratched. The variety of rocks yielded by careful search is great, and the original source of many yet remains to be found.

A pond on the south side of the road from Freeland to Church Hanborough, 300 yds. from the corner, showed three feet of pebbly loam resting on a foot of rudely bedded mottled sand. At North Leigh and New Yatt the drift is said to be 9 ft. thick, and to have a bed of gravel at the base which yields water. A patch occurs also at High Lodge at about the same altitude as the large spread at the Demesnes

Between the Evenlode and the Cherwell there are patches of drift capping Bladon Heath and Begbroke Wood, rising in places to 340 ft. O.D. East of the Cherwell no Unbedded Drift occurs within the area of the map, but the terraced gravels contain erractics.

South of the Thames the drift occurs on Seacourt Hill, 3 miles south-east of Eynsham. Pocock records several overgrown pits, showing quartzite, quartz and flint pebbles embedded in clay. The drift rests upon the slope of the hill, 270 ft. above the river but does not reach the summit, while the neighbouring Wytham Hill which rises 80 ft. higher, is free from drift. At Hurst Hill (520 ft. O.D.), immediately south of the Oxford-Cumnor road, a detached eminence is formed by an outlier of Lower Greensand with small patches of Gault; the drift occurs in hollows in the surface. Two such hollows, exposed in Chawley brickpit, appear to form parts of a channel crossing the hilltop from north-east to south-west. The drift shows traces of stratification and is about 12 ft. thick in the middle, where it rests on Gault, but thins away at the sides, and overlaps on to the Lower Greensand. The stones are well rounded or are subangular and include small boulders of a green-grey rhyolite. The deposit is apparently identical with that at the Demesnes.

The occurrence of the channel-like form of the deposit seen in Chawley brickpit has been explained by Pocock as follows (1908, p. 98):—

"The confusion of strata of different ages, which is so remarkable in the brick-pit, is probably due to several causes. In the first place the Kimmeridge Clay, though less disturbed than the overlying formations, has its bedding arched, as is shown by the lines of concretions. This may be due to the earth movements which gave the strata their present structural forms, but something may have been effected by dissolution of the subjacent Corallian Limestone by underground waters. The Ironsand rests on a denuded arch of the clay in a way that is peculiarly favourable to landslips. Whenever the surface of the clay is wetted by the percolation of water, the overlying sand tends to slip down on both sides of the arch, and much of the material is carried away by the springs thrown out on the hillside. Fissures and hollows are thus formed into which the Gault clay subsided. The process, though still in operation, had gone on a considerable extent before the drift was deposited, for it has affected the gravel to a much less extent than the Gault. Some disturbing effects might also be expected from the action of the ice, and this has confidently been appealed to as the cause of all the anomalies, but it is believed that the peculiar phenomena observed in the pit owe their origin in the main to the cause just described." Sandford (1926, p. 110) points out that if the deposits were laid down not by ice direct, but by outwash streams from ice near by, it is possible that the channel may have been scoured out and subsequently filled in. Sections in the area have shown considerable masses of gravel pressed into the underlying clay, with great disorder, suggestive of glacial processes.

Unbedded Drift of similar character occurs around Pickett's Heath Farm about a mile south of Hurst Hill, where at the north end of Boars Hill it reaches its maximum elevation (540 ft. O.D.) south of the Thames. A pit 300 yds west of the farm is stated by Pocock to have shown 8 ft. of gravel and sand, the pebbles being principally quartzite, vein quartz and flint, the last being much more abundant and fresher than in the deposits near the Evenlode. A little further north another pit showed smaller gravel, devoid of bedding, overlain by an irregular layer of stiff grey clay about 3 ft. thick. In the old pits at the farm, there is also a clay bed, weathered yellow, which has been considered to be a boulder clay by Sollas (1910, p. lvii),

Richardson examined the excavation for the Pickett's Heath reservoir, made in 1934, and states that it was about 12 ft. deep and that it disclosed mainly disordered blue, grey and green, yellow-streaked boulder clay with pebbles of Bunter type and flints associated so as to appear as pockets, veins, etc. The bulk of the boulder clay was free from erratics. The trench along the road to the south revealed many large quartzite pebbles and very fresh-looking flints associated with reddish quartzose sand.

The deposits at Pickett's Heath Farm fall to below the 500-ft. contour. The matrix contains reddish sand derived from the Lower Greensand. Numerous small patches on different parts of the hill are shown by pebbles in the soil. Other patches in Bagley Wood and Radley Park range from above 400 ft. to below 300 ft. Old pits by the Oxford-Abingdon road are 10 ft. deep. Among the pebbles here igneous rocks, possibly from Charnwood Forest, have been recorded and the abundance of rather fresh flints, presumably from the Chilterns, is to be noted.

The following petrological descriptions of tourmaline-bearing pebbles are supplied by Dr. J. Phemister:—

Erratic pebbles from the Witney area—

E. 17250. Sandstone with tourmalinized cement. The tourmaline is well crystallized, shows blue to colourless dichroism and is zoned with deeper colour at the periphery. Haematite and finely divided yellow material which shows aggregate polarisation are associated with tourmaline. The yellow mineral is sometimes optically continuous with the tourmaline. Rare grains of zircon.

E. 17251. Brecciated sandy shale in which the non-siliceous laminae are completely replaced by a multitude of tiny, dirty bluish green tourmaline prisms elongated parallel to the lamination. The tourmaline follows bending of the laminae and ends abruptly at the margin of the fragment. Some long tourmaline prisms are slightly curved and it looks as if this tourmalinization were anterior to the brecciation. Veins of quartz traverse the fragments and break sharply across the dirty green tourmaline bands, but contain many prisms of clear blue tourmaline. It appears therefore that the tourmalinization was effected in two stages.

Pebbles from the Bunter Pebble Beds, a mile east of Weeford, Staffordshire—

E. 17323. The rock is a tourmalinized breccia now composed of quartz, tourmaline and in some layers, abundant limonitic material. The fragments show lamination which is apparently the lamination of the original sediment since its direction changes from fragment to fragment. The laminae are are now picked out by concentration of blue and yellow-brown tourmaline. There are cross cutting veins of blue tourmaline. Cassiterite occurs in small aggregates of yellow crystals.

E 17324. The rock consists of yellow-brown tourmaline and quartz, the former being crowded as parallel-orientated prisms along lines which seem to be the laminations of a shale. The intervening mineral is extremely fine-grained and seems to be quartz. The rock is traversed by veins, now cross-cutting, now concordant, of granular feldspar (orthoclase) with quartz in places, and carrying blue-green tourmaline and a pale green hexagonal mineral. The latter is concentrated, usually in small radiating aggregates at the margins of the veins. In many of its properties this mineral resembles a mica but full investigation was not undertaken.

E. 17325. An extremely fine-grained rock consisting essentially of quartz and tourmaline. The latter is of the pale yellow variety and is concentrated in aggregates isolated in a quartzose base sprinkled with tourmaline prisms. Larger blue prisms of tourmaline occur along cracks filled with quartz. The rock contains areas with indefinite boundaries within which the grain of the yellow tourmaline is enlarged and in which blue and parti-coloured tourmaline are also present. Irregular grains of ore and some cassiterite, mostly opaque but often showing a yellow-brown colour, are numerous.

SARSEN STONES

Within the district there is a number of large blocks of yellow or greyish-yellow saccharoid sandstone resembling the Tertiary sarsen type of the Chalk country. Where seen, the blocks are generally not *in situ*, having been placed in hedges or alongside tracks. They range in size up to about 3 ft. in length and 2 ft. square. The surface is usually darker in colour than the interior, and is hardened and polished as if by sand blasting.

These stones are widely distributed and are found at any level from the alluvium of the Thames to the spread of Unbedded Drift above the 600-ft. contour at Wychwood. One was observed at the latter locality in the drift on the side of a small pond, though close to surface. It seems likely that these sarsens were introduced into the district with the glacial deposits, and may have been derived from Palaeozoic rocks.

RIVER GRAVELS

The river gravels consist of even- and current-bedded sand and gravel, formed mainly of oolite material, though scattered pebbles of northern origin, derived from the glacial deposits are also present. The gravels are arranged in terraces along the sides of the river valleys, and have been classified by Sandford (1924, pp. 113-179; 1926, pp. 118-152) as follows, the figures being the height of the various terraces above the level of the alluvium of the streams that they border :—

		Ft.
1.	Hanborough Terrace	70 to 100
2.	Wolvercot Terrace	30 to 50
3.	Summertown-Radley Terrace	12 to 25
4.	Flood-plain Terrace from alluvium level to	10
5.	Submerged channel	proved in borings.

Whereas the highest terrace is well defined and the lower terraces can be identified in most cases, there are areas where, owing to lateral movement of the rivers during downcutting, the gravels of adjacent terraces merge into one another. The best illustration of this is given by that part of the Thames above Standlake. Here the river has been constantly moving southward down the dip slope of the Jurassic rocks, and to the north of the present stream the gravels of the Summertown-Radley Terrace and the Flood-plain Terrace together form a mantle covering the gentle valley slopes from about 25 ft. above the level of the alluvium down to its margin, and furnish no feature by which the individual terraces can be separated.

HANBOROUGH TERRACE

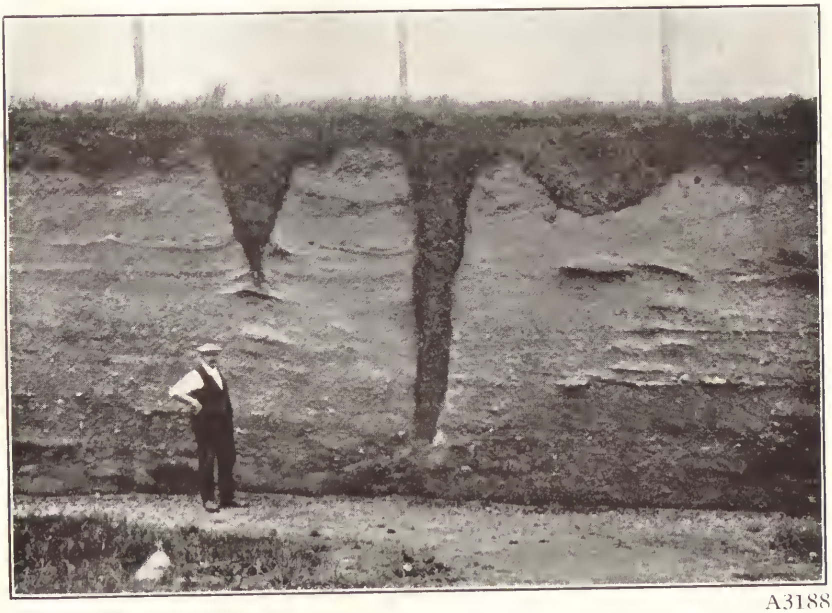
The Hanborough Terrace, from its situation, is regarded as the oldest of the river terraces. It occurs at elevations (70 to 100 ft. above the river) a little below the lower spreads of Unbedded Drift, except at Long Hanborough where the two deposits adjoin. The gravels of this stage have been much dissected and only small patches remain. On the left bank of the Thames, there are spreads at Lew, and at intervals downstream as far as Cassington, that at Long Hanborough being the largest spread within the area. Other patches occur east of the Cherwell at Bletchingdon and Kirtlington (north of Bletchingdon). On the right bank of the Thames above Oxford, the gravel of this stage has been removed by continual lateral erosion by the river and consequent shifting of the course down the dip-slope of the Oolites, but there are small patches near Radley Large Wood in the south-east corner of the area.

Local decalcification of the gravel of this terrace is frequent. In places the bedding of the gravel is preserved, though somewhat sagged, owing to the solution of the calcareous material. This type of decalcification is to be seen in the spread north of Bletchingdon. At Long Hanborough, there are steep sided pipes, with a clay lining, which have been infilled with material, apparently foreign to the gravel, in a manner similar to the solution pipes in the Chalk now filled with Tertiary debris. A remarkable phenomenon in connexion with this type of solution is the fact that the bedding of the gravel adjacent to the pipe is frequently turned upwards (*see* Pl. VIa).

The fossils of this terrace indicate a warm climate, *i.e. Elephas antiquus* Falconer and *Rhinoceros leptorhinus* Owen. No flint implements are known. Owing to their elevation above the level of the Thames these gravels are correlated with the Higher Gravels of the Plain of Cirencester district (Dines *in* Richardson 1933, pp. 85-91).

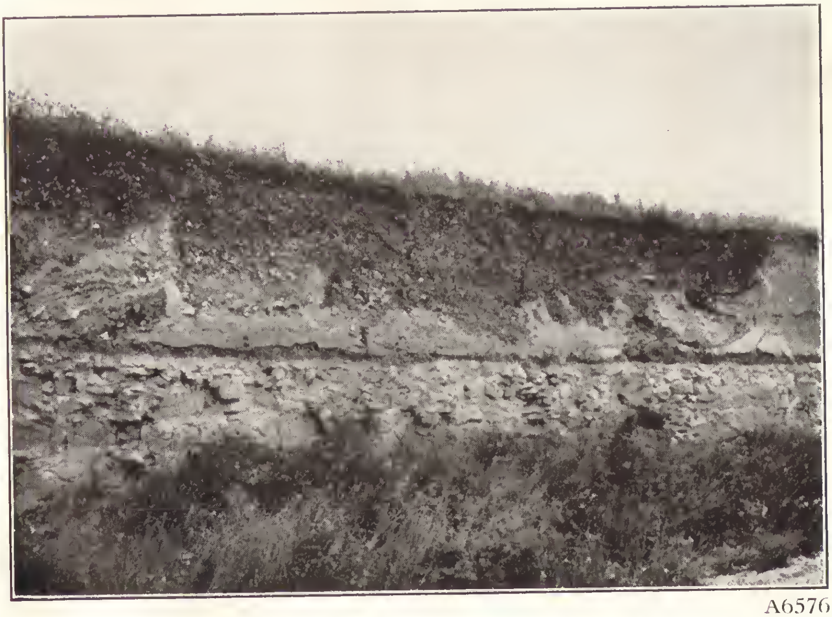
DETAILS

To the south of Lew, Hanborough Terrace gravel rests upon a bench in the slope that rises to the small hill, capped by Unbedded Drift to the west of the village. It lies a few feet below the 300-ft. contour, and between 70 and 80 ft. above the level of the Thames. A small pit east of Mount Owen Farm shows 1½ ft. of red-brown loam with stones on 3 ft. of bedded limestone gravel and sand, the top foot of which is disturbed. Other workings on the spread, 5 ft. deep, are overgrown. Around Barleypark Farm a considerable area of ground rises above the 300-ft. contour, and upon it rest three patches of gravel. On the most northerly, extending from Barley-



A3188

A.—PIPES IN HANBOROUGH TERRACE GRAVEL, DUKE'S PIT, LONG HANBOROUGH.



A6576

B.—HANBOROUGH TERRACE GRAVEL POCKETED INTO DECALCIFIED OOLITE, MESSRS. BREAKSPEAR BROS'. QUARRY, FISHER'S GATE, NORTH LEIGH. Immediately below the Great Oolite clay bed is the thin *Aphanoptyxis bladonensis* Bed.

park Farm to Moulden's Wood, the highest surface level is 328 ft. O.D. South-west of the farm and in the southern patch on Claywell Hill (310 ft. O.D.) small exposures show considerable decalcification. Occasional pebbles in the soil between the eastern patch which is not exposed, and that at Barleypark Farm suggest a once continuous spread. A small capping to Rickless Hill, north of Yelford, is shown by material thrown out from rabbit warrens. There is an irregular outlier on the hill west of Hardwick: 5 ft. of calcareous gravel with occasional small quartzose pebbles were seen near the cross roads between Yelford and Hardwick. On the east side of the Windrush there are patches at High Coggs, Tar Farm, South Leigh and west and north-west of Eynsham. Some of these show decalcification.

The largest spread within the area flanks the southern side of the Evenlode valley between Long Hanborough and Church Hanborough. Two large pits have been worked for many years and have yielded fossils. In a pit near the New Inn, Long Hanborough, the top 3 ft. of the deposit is disturbed, especially on the north side. The gravel consists mainly of limestone pebbles; it is coarser and looser near the bottom and contains quartzose pebbles and boulders, some striated, derived from the glacial deposits. There are some bands and lenses of coarse sand, and false-bedding is conspicuous.

The fossils found at the base of the gravel include *Elephas antiquus* Falconer, one molar being of archaic type, *E. trogontherii* Pohlig, *Equus* cf. *caballus* Linné and *Bos* cf. *primigenius* Bojanus, (*see* Sandford 1925, pp. 62-86).

In the pit at the fork of the roads from Hanborough to Witney and from Oxford to Stonesfield the gravel is 16 ft, thick, is evenly bedded with bands of sand and clay, and is composed mainly of small pebbles of oolite. Numerous large pebbles and boulders, often subangular, as well as smaller fragments, have been derived from glacial deposits. Fossils found near the bottom of the gravel are *Elephas antiquus* cf. *trogontherii, Rhinoceros megarhinus* Christol or *leptorhinus* Owen, and *Cervus? elephas* Linné. A Cellean hand-axe with heavy ochreous patination is recorded as from this district, but the position in which it was found is unknown. Pieces of flint, burnt, cracked and patinated white in the interstices have been found *in situ* near the base, which in these pits is 308 ft. O.D., 86 ft. above the Evenlode. Pipes, filled with a brown, gravelly, sandy clay, in the pits around Long Hanborough descend several feet from surface, and in some cases reach the bottom of the gravel. The cause of their formation is obscure, and their infilling appears to be subsequent to formation. The bedding of the gravel adjacent to the pipes is frequently turned upwards (Pl. VI A).

At The Row, to the west of Long Hanborough, the gravel abuts against the Unbedded Drift of The Demesnes. The junction was exposed in 1936 when a water main trench was dug alongside the Woodstock-Witney road. Sandford examined the section and states that at its western edge the gravel rested on an eroded surface of Unbedded Drift. The latter consisting of the usual sandy clay with pebbles and boulders of quartzose rocks, was a foot or two thick, with deeper pockets in the underlying blue Oxford Clay. At the base of the gravel there was a well marked iron pan some 4 in. thick. This consisted, in the main, of a cemented mass of small granular lumps of limonite, averaging about the size of peas, set in a buff coloured calcareous matrix. Quartzose pebbles were scattered throughout but no limestone pebbles were observed. The pan resembles bog iron-ore and may be earlier than the overlying gravel.

Two very small patches of Hanborough Terrace gravel are preserved on either side of the Evenlode gorge at quarter of a mile east of Wilcote House and at the same distance south of Oaklands Farm, about 80 ft. above the river. A few patches between North Leigh and Wilcote, are situated in a col which is cut through the Windrush-Evenlode divide between Crawley and Wilcote (*see* Pl. VI B). These occur below the level of the Unbedded Drift that occupies the col floor at its watershed near Hailey.

East of the Evenlode, gravel of this terrace, about 100 ft. above the river, occurs at Purwell Farm, north-west of Cassington, and at Spring Hill, west of Yarnton. A pit in the latter showed 3 ft. of decalcified and disturbed gravel resting on 3 ft. of normal oolite gravel (Pocock 1908, pp. 91, 92).

In the Cherwell valley Hanborough Terrace gravel caps plateau-like features at Bletchingdon and at Kirtlington to the north. Two pits in the latter spread, just within Sheet 218, show from 12 to 20 ft. of gravel, a noteworthy feature of which is the presence of large slabs of limestone resembling Forest Marble and Marlstone from the Lias. Irregular decalcified areas due to solution are rather darker in colour than the fresh gravel, and are crossed by lines of bedding, somewhat sagged. They differ in this latter feature from the pipes at Hanborough.

The section exposed in the more northerly pit is as follows:—

	Ft.
Grey-brown loam with scattered stones	1 - 1½
Orange to red-brown, clayey loam with quartzose and ironstone pebbles, festooned and disturbed ...	1 - 3
Rather coarse limestone gravel with some quartzose pebbles. Well bedded and finer grained towards the top. Decalcified irregularly to various depths. Lower layers with very large slabby masses of limestone ... ... seen to	8

The other pit is similar, but shows a greater thickness, and its gravel is not so coarse and contains layers of pink sand. Charcoal-like material, seen in patches along the bedding, does not appear to have been derived from the lignite of the local Jurassic rocks. Implements or burnt flints have not been found.

Below Oxford a few small patches of Hanborough Terrace occur in Kennington Wood and Radley Wood. It is not easy to separate the river gravel from the glacial deposits here, but oolite pebbles on the surface of the terrace deposits indicates fluviatile origin.

WOLVERCOT TERRACE

The gravels of the Wolvercot Terrace lie 30 to 40 ft. above the adjacent river level. They are confined to the present valleys, but have been extensively denuded and are preserved only in a few isolated patches. As yet nothing has been found to reveal the climate of this stage. An abraded Upper Chellean implement was found near Wolvercot, and a slightly abraded flake, possibly Acheulean, is recorded from Davenant road, Oxford, though its exact site is not known.

In the Cirencester area, to the west, the Lower Gravels of the plain lie at a height above the Thames similar to Wolvercot Terrace gravel within the present district. At Wolvercot the gravel of this terrace is cut into by a channel filled with deposits of later date. These are described under the heading ‘ Wolvercot Channel.’

Details

In the south-west corner of the area there is a row of patches of gravel of the Wolvercot Terrace, aligned approximately parallel to the present course of the Thames. They occur around Langford, Alvescot and Black Bourton, and at Windmill House north of Bampton, while what appears to be an old meander core is completely surrounded by later deposits at Weald. These patches lies from 30 to 40 ft. above the level of the Thames. They are, however, often approached in level by the alluvium of the small tributary streams that overflow from the Cornbrash across the Oxford Clay, with the result that waterlogging occurs periodically in places. Small pits are fairly common and show from 3 to 5 ft. of limestone gravel, with occasional quartzose pebbles, usually well-bedded and sometimes false-bedded. The upper layers, in many cases, are disturbed, and in exposures near Alvescot, are surmounted by contorted red-brown clay with scattered stones—the 'warp' of Sandford (1924, pp. 137, 138; 1926, pp. 140, 141).

On either side of the Windrush, near its confluence with the Thames, there are extensive spreads of gravel. Those that lie between Standlake and Hardwick and west of Stanton Harcourt rise from about 20 ft. to over 40 ft. above the level of the Thames. It would appear that these gravels include deposits belonging both to the Wolvercot Terrace and to the succeeding Summertown-Radley Terrace. Owing to the absence of features, however, it is not possible to separate them. A similar difficulty is presented by the gravel spread upon which Eynsham is situated.

Small patches of Wolvercot Terrace occur around Bladon Heath, at Burleigh Farm, north of Burleigh Wood and between Bladon and Begbroke Hill, while there is a large spread west of Thrup and a small patch north of Shipton on Cherwell.

At Wolvercot, an important area of gravel caps a plateau between the Thames and the Cherwell, and is separated from succeeding deposits by a narrow belt of Oxford Clay. The gravel, 4 ft. thick, is exposed in a large brick-pit between Wolvercot Cemetery and the railway bridge, where it is cut by a channel filled with later deposits, known as the Wolvercot Channel (*see* p. 123). Many temporary sections in the cemetery and in building excavations nearby have shown the general sequence given below. The base, though uneven, is at about 35 ft. above the level of the alluvium.

	Ft.
Fine loose gravel, calcareous, with, in places, a bed of false-bedded sand and fine gravel	3 - 4
Disturbed gravel ... ... about	1
Coarse ferruginous gravel with sharp sand	1 - 2
Loose regular grit and gravel, calcareous: locally ferruginous, especially at base; many large pebbles or small boulders from the glacial deposits, at junction with Oxford Clay ... ... about	2

In places the terrace is capped, and hollows in it filled, by contorted stony clay or sand, called 'warp' by Sandford. The junction of the warp with the gravel is distinct and uneven and the former does not appear to be due to decalcification of the gravel. It is notable that the bottom six inches or so of the warp are often earthy, though very hard when dry, and of a darker brown than the remainder. The deposit may be up to 7 ft. thick.

Excavations for foundations of the Clarendon Press building, north of the cemetery have shown that the gravel is bifurcated by a knoll of Oxford Clay, known to continue some distance into the cemetery, though gravel appears to be continuous a little further south. Near the north-west corner of the cemetery 3 ft. of fine-bedded limestone gravel with ironstone pebbles are overlain by 7 ft. of iron-sand and scattered pebbles and 3 ft. of top soil.

Two small patches of gravel belonging to this terrace lie to the north of the Wolvercot plateau at Peartree Hill. These are seen in an old brick-pit to be so disturbed that little or no bedding has survived. Quartzose pebbles are common, some showing striation.

In the south-east corner of the area, on the road south through Radley Large Wood, the gravel is 6 ft. thick and is cemented to a hard rock.

Terracing of the gravels is well seen in this area, with gravel spreads separated by abrupt slopes of Kimmeridge Clay.

The only fossil known from this terrace is horse from a pit at Conigre Farm. In a pit in the Wolvercot plateau, in Davenant Road, north of Oxford, was found a large flint flake, with creamy white patina, which may be Acheulean. It is about 6 in. long and 2 in. wide, and is now in the University Museum. The level at which it was found is unknown. Some rough ochreous implements, considered by Prof. Breuil to be probably Upper Chellean, tending towards Acheulean, were found at Peartree Hill by Bell (1904, p. 120; *see also* Sandford 1924, pp. 131, 132).

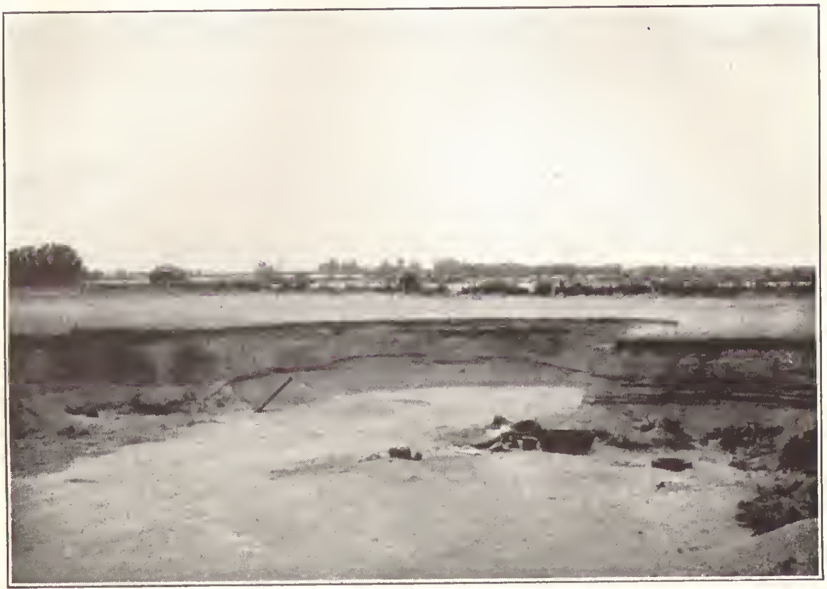
A correlation of gravels in the tributary valleys of the Windrush and the Evenlode based entirely on their elevation above the streams cannot be regarded as conclusive, since the tributary streams pass through narrow gorges and corresponding terraces above these gorges may not be separated by the same vertical interval as those within the Thames valley. There are spreads, however, which must be tentatively classed with the Wolvercot Terrace in the Windrush valley at about 1½ miles north-west of Witney and in the Evenlode valley at Chadlington (north of the present district) and at Milton under Wychwood. That, in the Windrush valley is small, and is situated on the shoulder of a steep cliff-like feature of the valley, about 30 ft. above the stream-level, opposite the blanket mill near Burycroft. Overgrown pits, show about 5 ft. of limestone gravel with some quartzose stones. Some seams of the sand appear to consist almost entirely of comminuted limestone.

The spread at Chadlington in the Evenlode valley (beyond the margin of the map) is 14 ft. thick. It is about 50 ft. above the river and thus is higher than the terrace at Wolvercot (Sandford 1924, pp. 128, 129). At Milton under Wychwood a small spread of river gravel apparently rests on a terrace feature cut in Glacial gravel. It is not exposed, though evidence of its limestone character can be seen in uprooted trees, etc. It lies at 35 to 40 ft. above the level of the Evenlode, and appears to have been deposited by the stream that drains the embayment of the valley slopes south and west of Milton under Wychwood. Miss Tomlinson (1929, p. 174 and pl. vi) correlates this spread with the Hanborough Terrace and regards it as being below the sands of glacial origin. Another spread to the south-east, at Upper Milton, has been worked to a depth of about 14 ft. It consists of densely packed subangular limestone fragments with occasional quartzose pebbles. It is roughly bedded, with wisps of loamy or sandy material. The top 4 or 5 ft. is contorted or disturbed. The small amount of wear shown by the limestone fragments indicate that the material has not been transported far, and, like the deposit just described, is probably derived from the limestone outcrops in the vicinity. The deposit has the appearance of being banked against one side of the present valley. Its relation to the glacial deposits nearby is not clear; it may underlie or overlie them and hence may be pre-Glacial or post-Glacial in age. Although described here, it is not suggested that this occurrence can be correlated with the Wolvercot Terrace.

SUMMERTOWN-RADLEY TERRACE

This is by far the most extensive of the terraces. Its base-level is about 15 ft. above the level of the Thames, though it ranges from about 12 to 20 ft.; its gravels have long been a source of water supply, and Oxford and many of the villages of the Upper Thames valley are situated upon them.

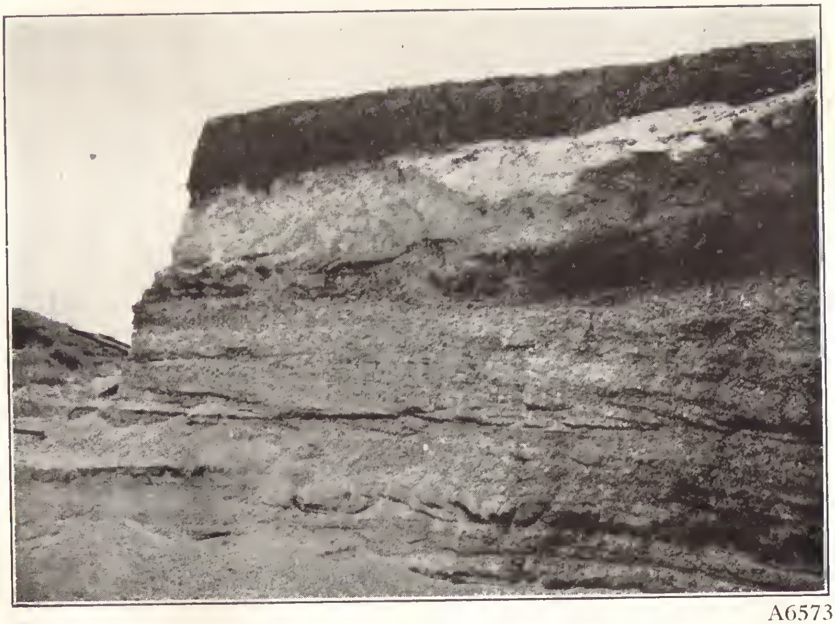
Owing to the lateral movement of the Thames, southward, down the dip-slope of the Jurassic strata, the gravel spreads to the north of the river cover a more or less uniformly sloping surface,



A6574

A.—LEVEL SURFACE OF THE SUMMERTOWN-RADLEY RIVER TERRACE, NEAR FOXLEY FARM, EYNSHAM.

The black streaks in the pit face are layers of gravel cemented by iron.



A6573

B.—GRAVEL OF THE SUMMERTOWN-RADLEY RIVER TERRACE, NEAR FOXLEY FARM, EYNSHAM.

This is a more detailed view of a part of the pit depicted in A.

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with the result that the Summertown-Radley Terrace and the Flood-plain Terrace in places merge into one another.

The deposits that belong to the Summertown-Radley stage are proved in a number of instances to be formed of an upper and a lower gravel, often easily distinguishable in pits. The lower bed has yielded a fauna indicative of a cold climate, *e.g.* mammoth, woolly rhinoceros, bison. The mammoth in most cases belongs to the true Siberian type, but there are a few specimens of the older 'Ilford Mammoth.' The surface of the lower gravels shows signs of erosion and channelling. The upper bed carries a warm fauna, *e.g. Elephas antiquus* Falconer, *Corbicula fluminalis* (Müller) and hippopotamus. Artifacts are rare; forms believed to be Chellean and Lower Acheulean, usually rolled, have been found in both beds of gravel. The upper gravels are frequently capped by contorted sand or clay.

At Eynsham, Cassington, Oxford (City Brewery) and east of Iffley, there is evidence that the gravel of this terrace fills a channel cut nearly to the present level of the Thames.

Details

From the western margin of the area at Langford to the confluence of the Windrush with the Thames, the northern slopes of the Thames valley are covered by gravels ranging from the level of the alluvium to about 25 ft. above. These comprise both the Summertown-Radley Terrace and the Flood-plain Terrace. The gravels mantle the gentle valley slopes without features of any kind to divide them into two terraces. The gravel has been dissected by tributary streams fed by overflow springs that rise at the upper boundary of. he Cornbrash and flow southward across the Oxford Clay to join the Thames. There are exposures here and there in small pits, usually about 5 ft. deep, and the gravel is seen to consist of normal limestone gravel with occasional quartzose pebbles. There is often water in the pits at 3 to 4 ft. below surface.

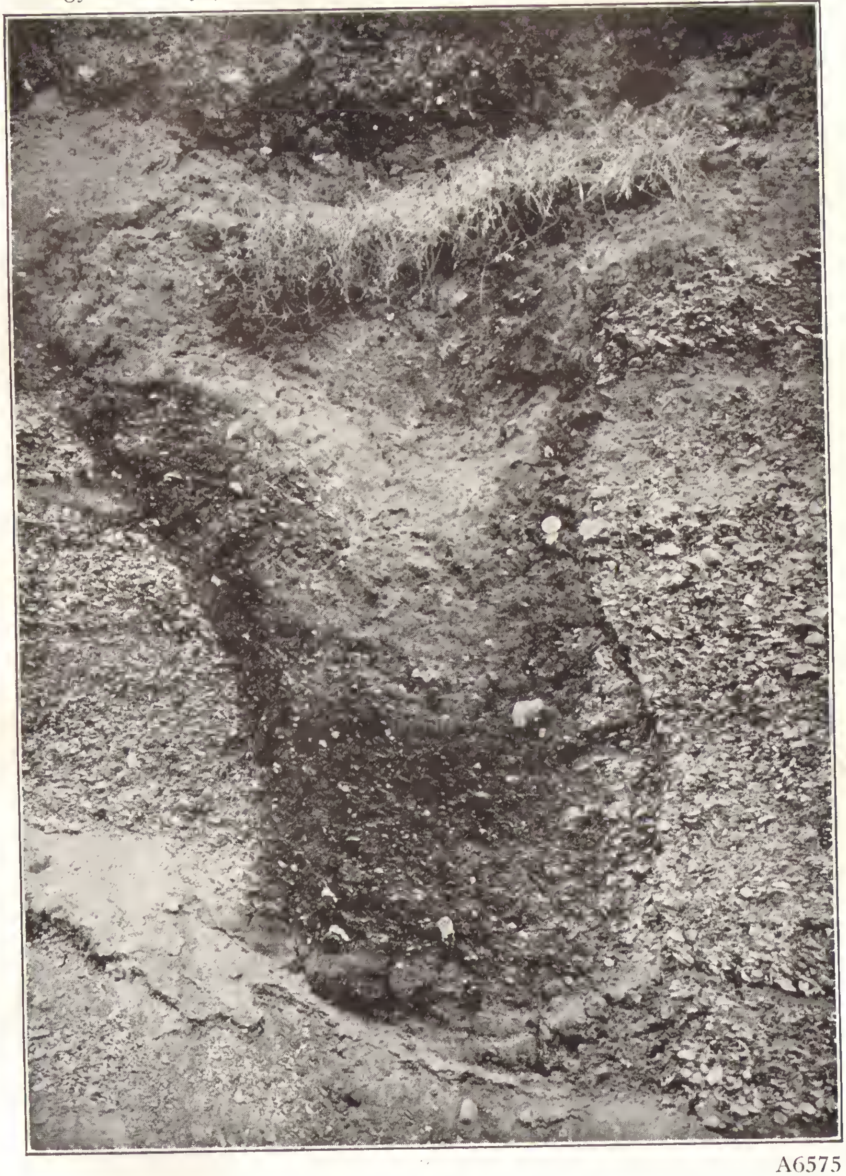
An exposure near Lower Farm, Black Bourton, and another at a quarter of a mile north of Cote, show a layer of whitish gravel cemented by calcite into a hard bed about a foot thick immediately below the soil. This bed rests in each case on bedded limestone gravel. White cemented seams are also seen in 5 ft. of gravel east of the village of Bampton. Pits in this neighbourhood are usually small; perhaps the largest are those situated in the north angle made by the intersection of the road and the railway at Langford Station; north of the road and half a mile north-west of Grayton, and in the village of Cote, east of the road to Shifford.

North of Brighthampton and Standlake, there is a marked feature between the Summertown-Radley Terrace and the Flood-plain Terrace. At the site of the British Village the gravel of the former terrace is 12 ft. thick. Along the banks of the Windrush here the base of the gravel can be traced by small springs thrown out by the subjacent Oxford Clay. The large spread to the west of Stanton Harcourt rises in places to the level of the Wolvercot Terrace, while it also adjoins the alluvium of the Windrush from Cutmill Farm to Beard Mill. It has been opened up in numerous pits, now mostly in disuse, which reach a depth of 9 ft., without touching 'solid' rock. Near the village the gravel is cemented by iron oxide into rock sufficiently hard to be used for building. The cemented layer is a foot or two thick and lies not far below the soil. The walls of the Norman nave of the church at Stanton Harcourt are built of rough blocks of this material, many of which, after nearly 800 years of exposure, show little sign of decay. The monoliths of the Devil's Quoits nearby are also of this rock.

The terrace continues northward to the mouth of the Evenlode but is dissected into patches by the Limb Brook and the Chil Brook. The gravel pit near Foxley farm is shown in Pl. VIII A and B. The spread on which Eynsham is situated rises to the level of, and apparently includes some gravel of the Wolvercot Terrace. Well sections near the town show considerable variations in the thickness of the gravel. Four wells near the station showed from 14 ft. to 21 ft., while near the landward margin and close to the river only 7 ft. is recorded. Between the railway and the Stanton Harcourt road, by Eynsham Station, extensive workings show from 8 ft. of gravel, increasing to 12 ft. to the south-west. A foot or so of ferruginous gravel at the base has yielded remains of *Bos primigenius* Bojanus, *Elephas primigenius* Blumenbach and *Cervus magaceros* Hart (Irish Elk, a unique discovery of this animal in the Upper Thames). Above the basement layer there is 7 ft. of gravel, clearly of later date, the top few feet of which is festooned. A well marked eroded surface separates this from overlying false-bedded gravel. The 7 ft. bed has yielded unrolled bones and teeth of Hippopotamus, *Bos primigenius* Bojanus, *Equus caballus* Linné, and *Cervus elaphus* Linné. A few shells were also found.

No exposures are known in the spreads between Eynsham and Church Hanborough, but behind the Bell Inn at Cassington, an 18-ft. pit has not reached the bottom of the gravel. Whereas the surface of this spread is some 20 ft. above the alluvium, its base approaches the level of the present river and may be below it. The thickness diminishes rapidly both north and south of the pit, and the great depth of the gravel here and at Eynsham Station may represent an old channel of the Thames. Similar deep channels are encountered in Oxford (City Brewery) and at Iffley (Cornish Pit), indicating a continuance of this line (Sandford 1924, pp. 145-148). At Yarnton, the gravel of this terrace is from 12 to 16 ft. thick. The pits (near the station) are now abandoned, but the deposit is stated to be " formed of many irregular, mostly undulating layers of gravel and sand with stripes of clay; . . . It yielded at and near the bottom, where large pebbles of Northern Drift formed an almost solid bed, a profusion of teeth and tusks of *Elephas primigenius* " (Phillips 1871, p. 463). Teeth of *Rhinoceros tichorhinus* have also been found at this level here as well as near Kidlington Station, at an unrecorded horizon. *Corbicula fluminalis* occurs in the gravel at Kidlington.

The Begbroke Hill spread is exposed in a pit (Partridge's Pit) on the south side of the lane that crosses it, and the following information is supplied by Sandford. Water-level stands at 12 ft. below the top of the gravel, and the excavation is carried 4 ft. below by mechanical excavators. The gravel seen above water-level is bedded, with many sand and clay seams, some showing finely laminated false-bedding. Bands of heavily ironstained gravel are persistent, especially near water-level. In addition to limestone pebbles, ironstone pebbles from the Middle Lias and quartzose pebbles from the glacial deposits are common. The top of the gravel is disturbed here and there and steep-sided pipes 3 to 4 ft. deep cut across the bedding. These are filled with limestone gravel and are covered by a foot or so of undisturbed gravel. There is a decalcified layer that reaches from 2 to 4 ft. below the soil and descends in pockets to 8 ft., where the decalcification fades off into patches of brown staining (see Pl. VIII). The decalcification is later than the disturbances that affect the top of the gravel. A molar of hippopotamus has been found and there are patches of comminuted shells of a fragile species like *Pisidium*. From the gravel below the water-level have been recovered teeth and broken plates of a molar of *Elephas primigenius* and a few large fragments of tusk. Some of these, thanks to the owners of the pit, are preserved in the Oxford University Museum. The surface of erosion between the upper and lower gravels, seen in some other sections on this terrace, is not clearly marked here.



A6575

SOLUTION PIPE IN SUMMERTOWN-RADLEY TERRACE GRAVEL, BEGBROKE HILL, NEAR WOODSTOCK.

The gravel is composed of rolled limestone fragments and northern material: from the pipe the limestone pebbles have been removed by solution.

From the base of the gravel, in a newer pit not far from the level-crossing, Capt. C. Mugrave has obtained a molar which Sandford identifies as *E. primigenius*. It is not of the Siberian form, but rather coarser and suggestive of *E. trogontherii*.

From Wytham, on the south side of the Thames, a valuable collection of vertebrate remains, now in the Oxford University Museum, includes *Elephas antiquus, Rhinoceros leptorhinus,* red deer and horse.

Oxford stands on a large spread of gravel belonging to this terrace that occupies most of the space between the Thames and the Cherwell. Towards the south the gravel appears to merge into that of the Flood-plain Terrace about halfway along St. Aldates, Oxford. There may be an outcrop of Oxford Clay between the two terraces near the bottom of the hill, but there were no exposures of this at the time of the survey. Northward of Oxford the spread extends as far as Summertown, beyond which the ground rises to the Wolvercot plateau. An important section in Webb's brick-pit, on the Woodstock road, showed the following section in the south-east corner :—

		Ft.	In.
8.	Soil	1	0
7.	Bedded gravel	1	0
6.	Disordered gravel and loam	1	0
5.	'Solution festoons' and disordered gravel	2	0
4.	Clay band rarely with valves of *Corbicula fluminalis*	0	2
3.	Bedded gravel, calcareous, with *Bos primigenius*	5	0
2.	Rubbly gravel, numerous teeth of *Elephas primigenius*	1	0
1.	Oxford Clay seen to	40	0

A slightly abraded boucher of Chellean type has been found, but the level from which it came is unknown.

Prestwich (1882, p. 51) published a long list of fauna from this pit, including mammoth, woolly rhinoceras, red deer, horse, etc., but gave no depths. He records (1882, p. 49) the following section at St. Edward's School, about 200 yds. east of Webb's pit :—

	Ft.	In.
Soil	1	0
Fine gravel with irregular black and ferruginous veins	3	2
Yellow sand with land and freshwater shells (*Corbicula fluminalis* and others numerous, with valves united)	3	6
Sand	3	0
Hard gravel	—	

Remains of *Elephas primigenius* were found below the shells. *C. fluminalis* has also been found at a similar level behind the playing fields of the school.

In his notes, preserved in the Ashmolean Museum Library at Oxford, the late P. Manning records having obtained, from an exposure in Lonsdale road, an implement at 10 ft. and a skull of a cave lion (*Felis leo spelaea*) at 7 ft. from surface. He describes the implement as long and pointed, plano-convex, slightly patinated and worn. In the University Park a large boucher of Chellean or Lower Acheulian type has been found, but not *in situ*. On the south side of the park, in the foundations of Dyson Perrin Laboratory, 18 ft. of gravel were excavated, and remains of *Bison priscus* and of mammoth were found near the bottom. Excavations for the boiler house, 50 yds. east of the Department of Geology, University Museum showed :—Disturbed ground, 3 ft.; well bedded gravel, 4 ft.; fine, false-bedded sand and fine gravel, 3 ft.; bedded gravel, fairly coarse, 6 ft., on Oxford Clay. Water was encountered 2 ft. above the base of the gravel. In the foundations of the

Girls' High School on the Banbury road two flint implements were found and many years ago single specimens were obtained in digging the foundations of the New Examination Schools, High Street and near Marston Ferry (Evans 1897, p. 593). All the above, with the exception of Manning's, are preserved in the University Museum and are regarded by Prof. Breuil as of Upper and late Upper Chellean: all are slightly abraded.

The gravel under the city of Oxford contains more sand and clay than further north. The surface is almost dead level at 210 ft. O.D. from Summertown to Broad Street. Carfax is higher, but may be artificially raised, and on either side the surface slopes gently towards the Cherwell and the Thames. The surface of the underlying Oxford Clay is shown by wells and foundations to be uneven; there is 15 ft. of gravel at Summertown, 9 ft. at Summer Villa, 6 ft. at North Cottage, 4 ft. to 6 ft. at Blackhall Farm and 9 ft. in Broadweld road. At some places the Oxford Clay comes nearly to surface; in others water is reached at small depths in the gravel, apparently held up in a hollow in the clay. At others again the gravel is dry nearly to its base. A borehole at City Brewery (surface 209 ft. O.D.) pierced 30 ft. of gravel before reaching Oxford Clay, and may indicate the existence of a deep channel of this stage, analogous to that at Cassington (*see* p. 120). Many lower jaws and teeth, of *Elephas primigenius* were found in the construction of the Holywell drainage system and the new Examination Schools (Prestwich 1882, p. 50). These are believed to have come mostly from the base of the gravel. One of the mandibles from the latter site is referable to *E. antiquus* (Sandford 1925, p. 77).

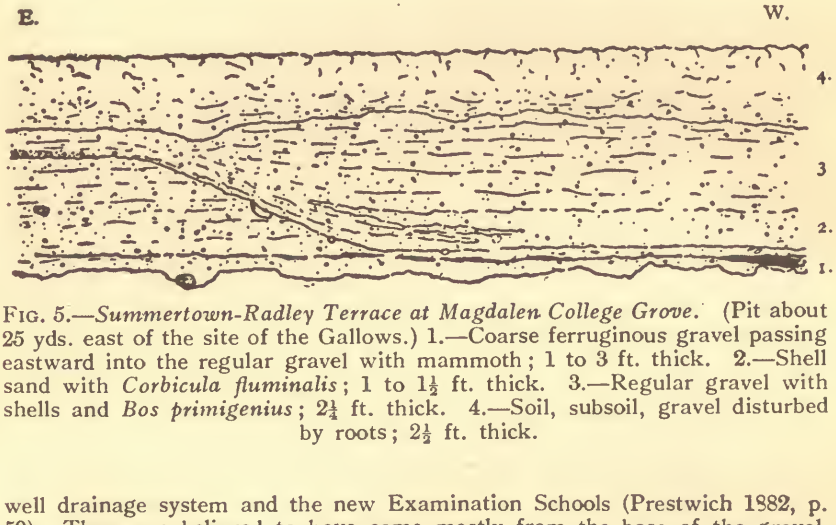


FIG. 5.—*Summertown-Radley Terrace at Magdalen College Grove.* (Pit about 25 yds. east of the site of the Gallows.) 1.—Coarse ferruginous gravel passing eastward into the regular gravel with mammoth; 1 to 3 ft. thick. 2.—Shell sand with *Corbicula fluminalis*; 1 to 1½ ft. thick. 3.—Regular gravel with shells and *Bos primigenius*; 2¼ ft. thick. 4.—Soil, subsoil, gravel disturbed by roots; 2½ ft. thick.

The faunal sequence observed at Eynsham and Summertown is explained by a section opened in the north-west corner of the Deer Park of Magdalen College shown in Fig. 5 (*see* Sandford 1924, pp. 142, 143).

On the east side of the pit, 3 ft. of regular gravel, very coarse and ferruginous at the bottom, contains many remains of normal Siberian mammoth. On the west side this bed has been eroded to a foot or so and replaced by 1 to 1½ ft. of cemented shell sand and gravel from which have been collected:—*Jacosta (Cernuella) virgata* (Da Costa), *Fruticicola (Capillifera) hispida* (Linné), *Cochlicopa lubrica* (Müller), *Limnaea pereger* (Müller), *Limnaea truncatula* (Müller), *Bithynia tentaculata* (Linné), *Valvata piscinalis* (Müller), *Unio littoralis* Lamarck, *Unio prestwichi* Kennard and Woodward, *Corbicula fluminalis* (Müller), *Sphaerium rivicola* (Leach), *Sphaerium corneum* (Linné), *Sphaerium radleyense* Kennard and Woodward, *Pisidium amnicum* (Müller), and *Pisidium henslowanum* (Sheppard).

The shell-bearing gravel overlaps eastward onto the mammoth gravel. In one instance a mammoth-tooth, partly projecting from the lower gravel, was seen to be covered by *Corbicula fluminalis* and other shells, in sand. Above the cemented shell band are 2¼ ft. of regular gravel which has yielded *Bos primigenius* only. The top 2½ ft. of the section consists of soil, subsoil; and disturbed gravel. Remains of bear, *Ursus anglicus* Gunther, was stated to have come from the mammoth gravel (Gunther 1923, p. 490). A similar sequence of deposits was noted in a pit a few yards to the north.

A small patch of gravel, south of Oxford and on the left bank of the Thames was exposed near its southern end in Cornish Pit. Though it clearly belongs to the Summertown-Radley Terrace, its base is nearly at present river level. The thickness of gravel here is 14 ft., the uppermost few feet being greatly disturbed by solution. It has yielded remains of red deer, horse, hippopotamus and *Rhinoceras tichorhinus,* and also Chellean bouchers, more or less rounded, one being of quartzite (Bell 1904, p. 129).

Deposits belonging to this terrace are not common in the tributary valleys. From its height of 15 feet above river level, the small occurrence occupying an abandoned meander at Asthall, appears to represent this stage in the Windrush valley. It is doubtful whether gravel occupies the whole of the ox-bow as shown on the map. A small pit west of the point where the line of Akeman Street crosses, shows 3 ft. of clean, irregularly arranged gravel of limestone fragments with a few quartzose pebbles, resting on jumbled angular to subangular blocks of limestone.

No gravel of this stage occurs within the Evenlode gorge, but in the higher reaches of that stream, there are patches near the mill north-east of Ascot under Wychwood, and on either side of the valley north of Shipton under Wychwood. The first of these yielded mammalian remains (Hull 1859, p. 58; *see also* Lucy 1872, p. 103). The others are the southern members of a chain extending up the valley as far as Daylesford (Sheet 217). The Glyme valley has no gravels. In the Cherwell valley there are small spreads at Marston, east of Oxford, at Kidlington Station, and at Hampton Gay. In a very small occurrence situated in the abandoned Tackley Meander (Davies 1923, pp. 92-94), in a pit quarter of a mile west of Whitehall farm shows :—

	Ft.
Red-brown sand, structureless but with horizontal streaks of colour in places, carrying scattered quartzose pebbles	2 - 4
Pockets of structureless red-brown decalcified loam festooning into pale buff to white coloured loam with angular fragments	0 - 2
Dirty clayey gravel	1
Fine-grained, even-bedded limestone gravel with many pebbles of ironstone and some quartzose pebbles. Thin layers of sand with small decalcified patches	4
Larger gravel, not well graded ... seen for	4

THE WOLVERCOT CHANNEL

The Wolvercot Channel is cut through a spread of gravel of the Wolvercot Terrace, just north of Oxford. Its deposits though of small extent, are of importance in that, in comparison with those of the terraces, they have yielded much evidence that throws light upon the Pleistocene history of the area.

The lower part of the channel contains gravel with a warm fauna. Implements include abraded Chellean and Lower and Middle Acheulean forms, and some large unworn implements which may be Upper Acheulean. There also occur a few unworn or slightly rubbed implements of La Micoque type. Above the gravel comes sand with freshwater shells of temperate facies. In one place the gravel and sand were, in turn, overlain by peat with a cold-temperate flora, including species now absent from the Oxford district, one limited to the North-West Highlands and another to Northern Europe. The sand is capped by 14 ft. of buff and blue clay and silt which have yielded remains of horse, deer and reindeer. The last is the only known specimen from fluviatile deposits of the district. Flint flakes suggestive of Mousterian, but not definitely of this age, are present. The clays are overlain by contorted sand, the two having a disturbed junction.

The channel thus contains evidence of a complete change from warm to cold climate. It is certainly later than the Wolvercot Terrace, in which it has been cut, and on the evidence of the fauna as well as of the implements, is believed to be later than the Summertown-Radley Terrace also (Sandford 1926, pp. 163-165; 1932, pp. 1-18).

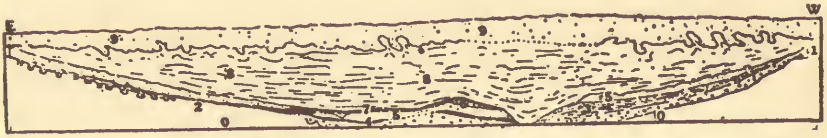


FIG. 6.—*Section showing the relations of the various beds of the Wolvercot Channel and the Wolvercot Terrace gravel.*
(Width about 60 yds., height about 20ft.)
O. = Oxford Clay. 1. = Terrace-gravel. 2. = Base gravel and swirl-holes (implements, bones.). 3. = False-bedded sandy gravel. 4. = Lower iron pan. 5. = Shelly sands. 6. = Fine gravel. 7. = Upper pan. 8. = Silt. 9. = Warp.

DETAILS

The channel cuts through the gravel of the Wolvercot Terrace, and some feet into the underlying Oxford Clay (*see* Fig. 6). A foot or so of calcareous gravel lines the bottom and both sides. On the east side there are numerous pockets or swirl holes, which appear to have been formed on the inward side of a curved course of the stream that formed the channel. In these swirl holes and in the thin gravel overlying them have been found, *Elephas antiquus* Falconer, *Rhinoceros leptorhinus* Owen, *Cervus elaphus* Linné, *Bos primigenius* Bojanus, *Bison priscus* Bojanus (?) and *Equus caballus* Linné, a warm fauna similar to that of the upper part of the Summertown-Radley Terrace. Associated with these are abraded Chellean hand-axes, and plano convex or slipper-shaped implements to which the term Wolvercot type is sometimes applied. These occur both in small and large forms, the latter up to 10 ins. in length. They are mostly unpatinated and fresh to slightly rolled. They are comparable with late Acheulean forms which approach the Levallois type. A series of small implements from this same horizon are regarded as being of the La Micoque industry.

On the west side of the channel, the basal gravel is partly overlain by a small patch of fine calcareous false-bedded gravel with some iron-oxide, and heavy iron pan of hard oolite gravel about 6 ins. thick covers both. This layer of pan seals the lower implementiferous gravel (one artifact of Lower or Middle Acheulean type has been found in it) and above it there is shelly sand containing an assemblage of mollusca which indicate temperate climate though *Corbicula fluminalis* is absent. The shell-sand is overlain by the upper pan which coalesces with the lower pan on the eastern side of the channel.

The surface of the deposits described above appears to have been eroded and finally the channel was filled in, to a depth of 15 ft., with silt and clay. Below the silt and clay, in one part of the exposure, Bell found a peat bed, probably deposited in running water, that yielded 30 species of flowering plants and 35 or 37 of mosses. About two-thirds of the plants still exist in the district, but *Hypnum capillifolium* Warnst. has been found in Britain only in the Arctic freshwater bed at Mundesley, and now occurs in high northern latitudes. *Thuidium decipiens* De Not. is an Alpine species found in Scottish Highlands but not elsewhere in this country. Five others, *Camptothecium nitens* Schp., *Dichodontium pellucidum* Schp., *Hypnum giganteum* Schp., *H. revolvens* Sow., *H. stramineum* Dicks. are sub-Alpine, not now living in Oxfordshire. Fragments of elytra of beetles found are all of existing species (*see* Sandford 1926, p. 139). The silt and clay though almost barren has yielded remains of horse, deer and reindeer (*Rangifer tarandus* Linné), and three flakes with creamy white patina, not referable to any particular industry. It will be noticed that the fauna of the base of the Wolvercot Channel has much in common with that of the upper part of the Summertown-Radley Terrace, though the implements point to rather a later culture.

The whole channel is capped by about 5 ft. of contorted sand (warp). Its junction with the clay is disturbed, and tongues of it are driven down into the latter. This capping appears to represent cold conditions, following the infilling of the Wolvercot Channel, and seems to have been laid down as a sludge or mass of partly frozen sand and gravel. Contorted deposits, resembling that at Wolvercot, are found, in places, on the Summertown-Radley Terrace, and the upper gravel of this stage frequently exhibits disturbance and festooning, probably a result of the same cold conditions.

FLOOD-PLAIN AND SUBMERGED CHANNEL GRAVELS

The Flood-plain Terrace rises to about 10 ft. above the alluvium. Locally patches are completely surrounded by alluvium, and owing to variations in level of the latter, gravels of the Flood-plain Terrace may be completely overlapped. The terrace is usually separated from the higher, Summertown-Radley Terrace by a marked clay-step, along which springs often issue, but in places the two merge into each other.

A submerged channel has been proved by borings and deep excavations, which also show that the channel deepens downstream, and that the gravels filling it are continuous with those of the Flood-plain Terrace.

The gravels of the Flood-plain and Submerged Channel have yielded no unworn implements, and the only fossil that can be regarded as indigenous is a large molar of Siberian Mammoth found at the bottom of the gravel in Christ Church Meadows, south of Oxford (Sandford 1925, pp. 82, 83). Antlers of red deer were also found here, it is believed, at a higher level. The skull of a hippopotamus, from the same site may have been derived from the Summertown-Radley Terrace.

Details

In the south west corner of the area, from Langford to Cote, gravels of the Flood-plain Terrace rise from beneath the alluvium but there are no exposures of note. The higher boundary is not traceable in the field, for the gravel merges into that of the Summertown-Radley Terrace. A small patch of gravel lying between the alluvium of two parallel tributary streams at Brize Norton appears to belong to this stage. Exposed in a temporary pipe trench this was seen to be from 2 to 4 ft. thick, and to rest on an irregular surface of the underlying oolitic rocks. From west of Brighthampton to Stanton Harcourt wide spreads belonging to this terrace flank the Thames bank on the left, while a low bank of gravel rises through the alluvium at Moorton. At Stanton Harcourt the gravel is partly covered by a wide spread of alluvium. Small banks rise above the surface of the flood-tract near Eynsham, at Lower Wolvercot, Binsey and on towards Oxford near Folly Bridge, and at New Hinksey. Trial bores for bridge foundations (Sandford 1924, pp. 148, 149) between Oxford and Botley proved at Pacey's Bridge, 12 ft. of gravel and peat below river level. On the Oxford side the peat formed the bottom, but thinned from 6 ft. to about a foot in the centre boring, and on the west side was replaced by gravel overlain by blue clay and river silt which passed into silt and gravel on the Oxford side. At Baslake Bridge, about the middle of the alluvial tract, gravel capped by yellow, and in one case black, clay was found from a depth of 16 ft. below river-level to 5 ft. above it. Gravel rises from below the alluvium to 10 ft. above it at Botley.

At the Oxford gas-works, which stands on alluvium, gravel has been found and the bottom not reached at 20 ft. South of the City there is a terrace along the margin of the alluvium. A small pit at Hinksey showed 7 ft. of gravel under 2 to 3 ft. of loam, and another in South Hinksey is said to have been 10 ft. deep in gravel. A trench crossing the island of gravel at New Hinksey proved gravel on Oxford Clay (Sandford 1924, pp. 148, 149). The surface of the gravel here is 5 ft. above the river level, and that of the Oxford Clay, 13 ft. below. South of New Hinksey, the trench, which followed the main road to Abingdon, turned across the alluvium, here up to 3 ft. in thickness on an eroded surface of gravel, which was not bottomed at a depth of 20 ft. The submerged channel is therefore over 15 ft. deep here. At Iffley lock it was proved to a depth of 25 to 30 ft.

In the valley of the Windrush there are small patches of Flood-plain gravel at the level of, or just above, the alluvium at Asthall, at the blanket mill north of Starveall Farm, at Little Minster, between Minster Lovell and Crawley, at the blanket mill near Burycroft, and to the south of Witney. Pits in these spreads show typical limestone gravel usually overlain by from 2 to 3 ft. of dark red-brown alluvial loam with scattered stones. The thickness of the gravel up stream is about 4 ft., east of Minster Lovell, 7 ft., and, south of Witney, 10 ft.

The only occurrence of gravel of the Flood-plain Terrace in the Evenlode valley is at Ascot under Wychwood. This is not now exposed. Hull (1857, p. 94) records elephant remains here, but Lucy (1872, p. 103) disputes this, claiming that mammalian remains were found in a small patch of gravel cut through by the railway cutting to the north-east of the village. The Glyme appears to have no gravel deposits of this stage, but the Cherwell valley, though almost completely covered with alluvium, has small patches of gravel west of Marston, at Kidlington, east of Shipton on Cherwell and at Enslow Bridge. There are also spreads adjoining the alluvium of tributary streams in the north-east corner of the area around Newbridge.

BRICKEARTH

The brickearth north of Wolvercot comprises the silt of the Wolvercot Channel. It is probable that the area, as shown on the map, is wider than the actual deposit of silt, which is masked by the overlying contorted sand. Except for the small unexposed patch in the Evenlode valley, south of Stonesfield, brickearth has not been observed elsewhere in the Witney district.

Recent Deposits

OLDER ALLUVIUM

In the south-west corner of the area, a flat tract of Oxford Clay country with spreads of gravel is partly covered by clay, some 2 to 3 ft. thick containing a few scattered stones. The deposit lies about 20 ft. above the level of the Thames alluvium nearby, and masks both solid and gravel spreads.

The clay was observed in the district around Little Faringdon in the Cirencester area, to the west (Dines *in* Richardson 1933, p. 87), but, as yet, too small an area has been surveyed and too few data collected to enable a definite idea of its mode of formation to be arrived at. It is clearly of later date than the river gravels, which it overlies, but of earlier date than the recent alluvium of the present streams which cut through it.

In appearance, it resembles an alluvium and it may be the result of ponding of waters on the Oxford Clay plain, but it contains scattered stones, amongst which flints, up to 4 or 5 ins. in length, occur in fair proportion. Quartzite pebbles are also present and limestone pebbles occur sporadically near limestone outcrops or near gravel spreads.

The deposit covers a flat area and has been mapped in the district around Langford and south of Broadwell. Much of the alluvium of the Cherwell, between Islip and Kidlington is above the present flood-level (Pocock 1908, p. 82), and may also be classed with the older alluvium, but generally no line of division between it and the more recent alluvium can be traced.

ALLUVIUM

The alluvium, or river mud, occupies the bottoms of the present valleys of the district. It is from 6 to 8 ft. thick in the more central parts. Where the rivers traverse harder rocks and well defined valleys are formed the margins of the alluvial tracts are well defined, but in the low-lying clay districts the alluvium thins gradually from the rivers, and no definite boundary is determinable. Freshwater and land shells, all of living species, occur abundantly in places, as at Water Eaton on the Cherwell. The alluvium rests upon solid rocks or upon gravels of the submerged channel. Usually there is a sharp line of demarcation between the alluvium and the gravel, the former apparently resting upon an eroded surface of the latter. A temporary section of Iffley lock, however, showed the gravel to be overlain by 4 ft. of silt and sand with shells and that by 4 ft. of dark mud in which bones of horse and ox were found. There was no clear line of partition between the shelly silt and sand bed and the underlying gravel. The shells have been declared by A. S. Kennard to be of Holocene age. Peat beds interbedded with the alluvial mud have, in places, yielded Roman remains at shallow depths (Cobbold 1880, p. 319).

The alluvium does not follow the rivers with perfect uniformity but tends to form lake-like expanses at slightly different levels, separated by narrow passages, as, for example, the wide alluvial tract east of Stanton Harcourt, between the narrows at Shifford and at the foot of Wytham Hill, and the spread of alluvium covering Flood-plain gravels east of Wytham between the latter passage and the Sandford gap, south of Iffley. This appears to be due to ponding of flood waters behind the narrows.

In the Windrush valley alluvial mud is deposited in some places on ' solid ' rock and in others on top of the gravel, but in a number of places it does not rise sufficiently high to cover all the Flood-plain gravel. Excavations made in 1933 for the bridge at Swinbrook proved alluvium 6 ft. thick on Upper Lias clay. According to Richardson, artificial obstructions have assisted the natural process of filling-in the valley. The practice of attempting to prevent flooding by throwing up banks alongside the stream has caused it to heighten its bed and so has aggravated flooding in very wet periods.

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CHAPTER XII

ECONOMIC GEOLOGY

Soils and Agriculture

By C. G. T. Morison

THE agriculture of the area has been principally determined by two factors, (1) the character of the soil, which is mainly dependent on the lithological character of the parent rock, and (2) the proximity to markets for the delivery of perishable commodities. In late years, with the development of road transport, this latter factor is becoming of less importance and in the future soil may be used acording to its inherent suitability for a particular purpose.

The soils of the district divided it naturally into three regions :—

1. The area of oolitic limestones of the north-west.
2. The valley of the Thames, consisting of Oxford Clay covered with patches of alluvium and gravel.
3. The area south of the Thames in which there are outcrops of Corallian limestone and sand and of Kimmeridge Clay.

1. In the first of these occur red and black calcareous soils, the distribution of which appears largely to depend on the site and the general utilization of the soil. Red soils occur on the plateaux and southern slopes especially where they are under arable cultivation and black soils, showing the properties of the typical rendzina of continental writers, are to be found mainly on the northern slopes under forest and sometimes under grass. In all cases the agricultural value of this land is closely associated with the depth of soil. A heavier type of soil with the properties of a brown forest soil occurs on the clays in Wychwood Forest. In the valleys of the Evenlode and Windrush are found meadow soils which show to a greater or less extent the effect of a high water table.

The agriculture of this area has for many years depended mainly upon sheep, and this is still characteristic of much of the Cotteswold area. The land is suitable for sheep and barley and is almost ideal for the breeding and rearing of typical arable land sheep like the old Cotswold breed, which has now almost disappeared, and its successor the Oxford Down.

The farms are large and often ill-planned for economical working in these days of expensive labour. In many cases they stretch from the Windrush valley, in which the house and buildings are situated, up to the high downs a mile or more away.

The country may be regarded as an area of extensive rather than intensive agriculture, as the thin stony soil is not a sufficient guarantee of adequate water supplies in dry seasons to make heavy expenditure on fertilizers a profitable investment. It has been, until recently, mainly a country of arable farming, but with the increased cost of labour and the low commodity prices much of the poorer land on the higher situations has been put down to grass. With this change the sheep of the arable-land have, to some extent, been replaced by grassland sheep from the north of England or the borders of Wales.

Although the land was formerly considered quite unsuitable for dairying there has been some development of milk production in recent years. This has been encouraged by the relatively good profits from milk (compared with those from arable sheep farming or store cattle rearing). It has also been facilitated by the introduction of improved grass-seed mixtures containing drought-resisting grasses and wild white clover.

2. In the Thames valley, and on the lower parts of the valleys of the tributary rivers, the parent material of the soils is mainly clay, and the drainage conditions are poor. Meadow soils or soils of impeded drainage occur and the type of vegetation associated with these varies in accordance with the depth of the water table. Scattered over the area are many patches of river gravel, consisting mainly of limestone pebbles which give rise to a soil resembling in many respects that of the limestone areas.

Milk has for long been one of the principal products of this region, and the considerable area of grass-land on the heavier soils has been the mainstay of this type of production. The meadows close to the river Thames are not very productive and, so far, have not shown themselves capable of much improvement. Much of this area is liable to flood, and the majority of the villages and buildings are situated on the patches of limestone gravel which are scattered over the valley. The gravel patches also carry almost the whole of the arable-land of the district. The soil is light and easily worked, and is useful sheep and barley land. It has been farmed in the main in a manner simliar to that of the true limestone region already described. The whole of the country is flat and liable to become waterlogged in a wet winter and to dry out rapidly in the spring and summer so that success in agriculture demands a dry winter and a moist summer.

3. South of the Thames the outcrops of Corallian sand and limestone give rise to characteristic soils, the former a slightly podsolised brown earth and the latter a limestone soil similar in many respects to that formed on the oolitic limestones. The Kimmeridge Clay gives rise to typical brown forest soils, good

examples of which, associated with their typical vegetation, can be seen in Bagley Wood. On the plateau gravels well developed podsols may occur on suitable sites.

Much of the land is close to Oxford and the farming is of the varied kind usually found in proximity to a town. Dairy farming finds a place on the heavier soils and there are considerable areas of market garden crops on the lighter soils, where also fruit orchards have recently been planted. The heavy soils of the Oxford Clay which occur on the right bank of the river carry characteristic grass land which is capable of considerable improvement.

For fuller information on agriculture and soils the reader is referred to Pizer (1931) and Orr (1918*a & b*).

Building Stone

The Marlstone in the Evenlode valley has been used in one or two buildings at Fawler. These are now in ruins, but the blocks, which take a satisfactory dressing, are nearly as fresh as when first used (*see also* Hull 1859, p. 10).

The Chipping Norton Limestone has been used to a small extent for field-walls and barns on and near its outcrop, and a considerable quantity was quarried in the Buckleap Quarry, Cornbury Park. The Chipping Norton Limestone is exposed to a depth of 23 ft., and in places is overlain by some 26 ft. of Taynton Stone. According to Mr. John Kibble of Charlbury (*in. litt.* 29. 5. '35), " much of the upright face of Blenheim Palace is done from Cornbury Stone." The building of the palace commenced on the 18th June, 1705.

The Taynton Stone of the Great Oolite Series was quarried for several centuries in the neighbourhood of Burford, as in the Taynton Quarries (Sheet 235) and Upton Quarry, and attained a considerable reputation. It was known to Plot and Robert Hooke in the time of Charles II as ' Burford Stone,' but subsequently ' Taynton Stone ' became its commercial name and this appears to have been adopted for the geological stratum by Woodward (1894, p. 307). More recently the bed has been worked in the Milton Quarries, Swinbrook Quarry and Buckleap Quarry.

Upton Quarry, which in turn was known as Whiteladies' and Kitt's Quarry, furnished stone for the building of Christ Church, Oxford, and for the columns, mouldings and tracery of St. Paul's Cathedral. The Milton Quarries were worked by Messrs. Groves Bros. from 1846 onwards for about fifty years. They were then acquired by a firm that afterwards traded as The Taynton and Guiting Quarries Ltd., who opened the Coscombe Quarry in the North Cotteswolds and abandoned the Milton Quarries. The limestones that were worked at Milton obtained considerable repute in building circles and were of two kinds. One was derived from the whitish beds of White Limestone that weather into large blocks, and the other from the yellower Taynton Stone at the base. It is important to note that in the trade both kinds were called Taynton Stone, the former (White Limestone) being known as " No. 1 " and described as " a fine-grained cream-coloured oolite," and the latter (the true Taynton Stone) as " No. 2 " and stated to be a " similar stone, but a shade warmer." The quarries are mentioned in the manorial Account Roll of Burford of 1435-6 (pt. III, p. 318) and as Whichelate Quarry in the Survey of Edward VI. The White Limestone, except in the Milton Quarries, has been little quarried for building-purposes (*see* Richardson 1910*a*, p. 537).

The Kemble Beds have been worked in many quarries for building, walling, flagstones, burning for lime, foundations for roads, and road-metal, and there are many places where the beds could be readily opened up if desired. In the neighbourhood of Brize Norton they have been extensively quarried, mostly for the flagstones, but building-stone was also obtained. In the neighbourhood of the Cotswold Gate Hotel, Burford, the main part of the Kemble Beds is a hard, yellowish, somewhat shelly, oolitic limestone: the houses called " The Leaze " are built of rock quarried on the west side of the road. In the Station Quarry, locally known as ' Sougrwpt ' Quarry, Hanborough, blocks, mostly small, are obtained. These take a satisfactory dressing and appear durable. Kemble Beds are worked in the Gibraltar Quarry, Bletchingdon, and at the present time provide for foundations for roads.

The Cornbrash is too rubbly for building purposes, and the Coral Rag and the Wheatley Limestones have been worked only for local requirements.

TILE-STONES

Stonesfield Slate.—' Slates ' or ' slatts ' or more correctly tile-stones have been worked at Stonesfield, certainly from Roman times. Probably it was ' presents ' that first attracted attention. These are pieces of the bed, or ' pendle ' as it is now called, that have become detached by weathering at the outcrop and lie about loose and ready for use after a little trimming. At first the slate was obtained by means of open workings and headings driven in from its outcrop. Then as the pendle thus available became exhausted, shafts were sunk and the stone ' foxed ' by means of galleries three feet high. They were perfectly dry, and became very extensive. On the old 6-inch Ordnance map, the survey for which was carried out in 1878-80, the sites of ten shafts are shown and several more were put down subsequently. In the part of Stonesfield village near the War Memorial, Barrett's shaft, which was descended by Woodward, was 66 ft. deep to the pendle, that in Crown Field by the side of the Woodstock road (visited by Hull (1859, p. 18) in 1857 or '8 and worked at the time with a horse-gin), 64 ft. deep, and Davis's shaft in Busby's Close, 60 ft. deep. The industry is now extinct and the last slatter died in 1933.

The last slate working, near Spratt's Barn two-thirds of a mile due west of Stonesfield Church was closed at the end of 1909 (Richardson 1910*b*, p. 29). According to Mr. George Poole of Stonesfield (12. 9. '33) the depth from the surface to the pendle here is 22 ft., while in another shaft in the same field, a little to the north-east, it is 30 ft.

There is still some demand for the ' slates.' The leading builders in this part of the country obtain them from old buildings when they are demolished, though at Burford a few have been obtained recently from the Eyford district in the North Cotteswolds (Richardson 1929, pp. 144-146). Many of the new houses in the limestone country are roofed with tiles which come from Leighton Buzzard and are coloured to resemble the natural ' slates ' of the district.

The extent of the tract at Stonesfield in which good material was found appears to be small. It is probable that the waste-heaps of the old workings and the sites of the shafts indicate approximately its extent. This is borne out by early and recent geological researches and by local opinion. Hull said (1859, p. 18) " The slate producing district is apparently included within a radius of half a mile round the village of Stonesfield, though it is uncertain whether equally good slates might not be found further towards the north and east," and, in a footnote, " Workmen say, that on the east side of Bagg's Bottom [that is, the valley to the south-east of Stonesfield along which runs the Akeman Street] the slate bed dies out." " Over a considerable portion south and west of the village the slate has been exhausted," and recent local opinion is that " practically all the slate has been got." It is not likely, as suggested by Hull, that there is an occurrence of good slate to the north and east.

The position of the industry a year or two previous to 1894 and the method of getting and preparing the ' slate ' has been described by Woodward (1894, pp. 310-312, 484, 485).

Forest Marble.—Large flagstones, or ' plankstones,' ' planking ' or simply ' planks ' as they are variously called, used for paving, etc., were formerly obtained on a large scale from the Kemble Beds (that is, the lower part of the Forest Marble as represented on the map, in the south-western part of the district) at Bradwell Quarry (p. 43) and the Brize Norton pits. Many may still be seen set erect, serving as walls to gardens. According to Plot (1677, p. 77) " . . . at Bradwell they dig a sort of flat stone, naturally such, without help of winter, and so strangely great that they have them 7 ft. long and 5 ft. over." Wychwood Beds come on to the south-east of Burford and the thinner flagstones amid the clays appear to have been worked for tilestones long ago, according to the manorial Roll of Burford of 1435-6 (pt. III, p. 318) in Sterte and Le Wort Quarries. In the Survey of Edward VI, Sterte Quarry appears under the same name, but Le Wort Quarry as " le Slatte quarry lying in Signet." The flaggy beds are well exposed in the old quarries at Brize Norton. About 1845 as many as twenty teams of horses were employed in carting the stone (Woodward 1894, p. 371). At the present time the only quarry where the better flagstones are utilized as such is the small one near The Pit, two-thirds of a mile north by east of Kencott Church (p. 40).

In the extreme north-eastern part of the district, in the parish of Bletchingdon, the Kemble Beds were actively worked for flagstones, etc., for many years, in the Gibraltar Quarry (p. 67). Probably it was from this quarry that the stone was obtained of which Plot wrote (1705, p. 79) : " . . . a sort of Grey Marble [is] dug in the parish of Bletchingdon, in the lands of the Right Honourable Arthur, Earl of Anglesey : of this there are several chimney-pieces and pavements in his Lordship's house there, well worth the notice; as also at the Right Honourable the Earl of Clarendon at Cornbury. And of these are the pillars of the portico at St. John's College in Oxford. They make beside of it tombstones and tables, and of late mill-stones . . ."

Tile-stones have been obtained from the Wychwood Beds part of the Forest Marble in the extreme south-western part of the district (Bradwell Quarry) and at Witney where in large quarries to the north-east of Witney Cemetery, now overgrown, the Wychwood Beds clay, according to Horton (1860, p. 252), " is divided about the centre by a band of slaty sandstone, which, although not equal to the Stonesfield Slate for the purpose, is capable of being worked by the hammer into a rough kind of roofing tile." It is likely that this local tile-stone has been used in Witney.

Tile-stones were obtained from the Wychwood Beds at Whiteoak Green, according to Hull (1859, p. 22).

A part of the remnant of Wychwood Forest is named Slatepits Copse on the 6-inch and 1-inch (Sheet 236) maps. ' Slates ' have not been worked here within the memory of anyone now living in the neighbourhood and inequalities in the ground alone mark the sites of the pits, but the slate that was obtained here would appear to come from the same stratigraphical horizon as that at Whiteoak Green.

The Wychwood Beds of Wychwood Forest and neighbourhood contain thin limestones, replete with bluish tinted oysters, which have been polished and used for mantel-pieces, etc.

Bricks, Tiles and Pottery

At the present time the only active brick and tile works is the Chawley Brickworks, Cumnor Hill, near Oxford. In the past bricks have been made from the uppermost clays of the Lower Lias, near Ascot under Wychwood, and from clays on about the same horizon together with overlying Sandy Beds of the Middle Lias at Fawler.

The Oxford Clay has a wide extent in this district and is well known as excellent for brickmaking, but now no pits are open. The last pit to be worked was at Upper Wolvercot: other pits were: (1) at Peartree Hill to the north of Wolvercot; (2) adjoining Keble College cricket ground at Summertown; (3) at St. Clement's near the workhouse on the Cowley road from Oxford; (4) Barnard Gate between Eynsham and Witney; (5) Breakspear's Brickworks near The Demesnes, Long Hanborough; (6) half a mile west of Combe Church and (7) Leafield, locally called 'Fieldtown.' The brick and pottery works at Leafield were situated a little beyond the Baptist Chapel and nearer the village. They produced hand-made bricks, agricultural pipes, glazed pans and jugs ("pitchers") until about 1915. From a brick and tile works on the northern outskirts of Aston village, east of Bampton, tiles in large quantity were widely distributed.

Kimmeridge Clay is dug at the Chawley Brickworks, where bricks, tiles and pipes are made, and was also used at brickworks near Yatscombe Farm and at Foxcombe Hill in the Boars Hill district.

The fluviatile loam of the Wolvercot Channel forms a good brickearth of a kind not observed elsewhere in the district (Pringle 1926, p. 178).

SAND AND GRAVEL

There is an abundance of siliceous sand in the superficial deposits of the district and a little in the 'solid' formations. There are some old pits in the sandy limestones and sand in the Forest Marble which give rise to a tract of heath-land north-east of Swinbrook (p. 52), and near Bradley Farm, Cumnor, sand in the Lower Calcareous Grit is worked for use at the Chawley Brickworks.

In the Evenlode valley sand of the superficial deposits has been worked at Milton under Wychwood and is got intermittently, for use on the Cornbury Estate, in a small pit about a mile east-by-south of Shipton under-Wychwood Church. The pit at the former locality is at the southern end of the village: it shows 12 ft. of red sand, with occasional small quartzite pebbles, that locally overlies limestone gravel of variable thickness (p. 107). The sand extends southwards into the northern part of Upper Milton where there is a pit in the limestone gravel. An average sample of the sand in 1935 gave:—Silica, 90.70 per cent.; alumina, 3.54 per cent. It is said to be useless for mortar as "it is too fine and eats up the lime." According to Dr. W. F. Fleet "the Milton sand is like Midland Upper Bunter, fine and non-micaceous, and the residue is quite like a typical Bunter residue." The sand deposit to the eastward of Shipton is of small extent, but has been worked to a depth of 9 ft. without reaching the base: it contains sparsely distributed pebbles (p. 108).

The Unbedded Drift has been worked for gravel as, for example, north of Stag's Plain (p. 109), and it contains some sand, but except for the sand of The Gorse Field, Ramsden (p. 110) both gravel and sand have a considerable admixture of clay.

The chief sources of gravel and sand in the district, however, are the Hanborough and Summertown-Radley Terraces of the Thames: the Flood-plain gravel is, as a rule, dirtier, i.e. has more clayey matter associated with it.

Small pits used to be numerous, but are now superseded by a few with machinery for separating and washing. Large pits in the Hanborough Terrace at Hanborough are the Duke's, Henry Haines's, Lady Smith's, and C. Wastie's; in the Summertown-Radley Terrace, C. Partridge and Sons' pit at Begbroke Hill, at Cassington, near Foxley Farm south-west of Eynsham, Linch Hill south of Stanton Harcourt, and Standlake; and in the Flood-plain gravel, at Filchamstead, Cumnor, and Ducklington near Witney.

LIME

The White Limestone subdivision of the Great Oolite Series covers a considerable area and has been worked on a small scale for burning for lime in numerous quarries. At present the only quarry where it is worked for this purpose is that of Messrs. Breakspear Bros. at Fisher's Gate, North Leigh, but the rock is quarried extensively together with the overlying Kemble Beds by the Alpha Cement Company at Shipton on Cherwell.

A typical sample of hard, white, lithographic limestone from the quarry about halfway between Swinbrook and Fulbrook has been analysed (26. 1. '35) by Mr. C. C. Duncan, F.I.C., F.C.S.:

ANALYSIS OF WHITE LIMESTONE

	Per cent.
Moisture	0.2
Insoluble matter	1.1
Iron and alumina (Fe_2O_3 and Al_2O_3	1.5
Calcium carbonate ($CaCO_3$)	97.2

Kemble Beds are quarried for lime-burning at East End Quarry, North Leigh (p. 56). The lime is said to be preferred by many brick-layers to that made from the White Limestone as it is more 'fatty.'

The Coral Rag and Wheatley Limestone are burned locally on a small scale as at quarter of a mile south-west of Wootton Church

Road Metal

Most of the hard beds in the various formations have provided road material, but of recent years only the White Limestone has been quarried to any considerable extent for the purpose—principally for foundations or ' pitching ' in connexion with the Burford-Witney road and the Oxford Northern By-pass road from Eynsham to Oxford. Quarries in work at the present time are: (1) in the White Limestone :—Tolley's Quarry and The Old White House Quarry, Bladon; Layshillwood Quarry, Long Hanborough; Werrell's Quarry, Fisher's Gate, North Leigh; Haines' Crawley Road Quarry, Witney; and, for metal for local roads, a quarry about halfway between Swinbrook and Fulbrook: (2) in the Kemble Beds :—Gibraltar Quarry (" Upper Greenhill Quarry "), Bletchingdon.

Local gravel is used to some extent for surface metal: in the neighbourhood of Charlbury gravel from Dean Grove, a mile to the north-west of the town, is much used.

Iron Ore

The Marlstone becomes increasingly ferruginous from west to east. The occurrence of Marlstone at Fawler, with an iron-content apparently sufficiently high to make it worth working, was detected by Hull during the original Geological Survey of the district and its exploitation under the name of Blenheim Iron Ore commenced almost immediately. The quantity of ore raised increased from 1,200 tons in 1858 to 5,600 tons in 1861; no independent returns were issued in later years and the workings were discontinued in 1887. At the present time little is visible and for information the reader is referred to the literature (Hull 1859, pp. 10-12; 1860, p. 304; 1861, pp. 81, 82; Woodward 1893, pp. 220, 303-306; Lamplugh and others 1920, p. 124).

Water Supply

A large part of the area here described lies on the outcrop of the Oxford Clay. It is, therefore, not surprising that underground sources of water supply are of minor importance as compared with rivers. The majority of the villages in the Witney Rural District are in the process of being supplied from the Witney Urban District Council's undertaking which utilizes the River Windrush; similarly, those villages of the Abingdon Rural District, that lie within the present area are to be supplied by the Oxford City's Waterworks, which obtains water from the Thames. Woodstock Borough is also supplied from Oxford.

The floor of the Evenlode valley down as far as the vicinity of Charlbury lies in the Lower Lias. Approximately the upper two-thirds of the Lower Lias is almost entirely clay. Wells sunk into it receive only a very slow seepage, but if they pierce a limestone a little more water may be available. At times much of the water collected in wells in the Lower Lias, especially if they are inadequately protected, is surface water that has percolated through cracks in the clay ground. The water is, as a rule, hard and locally may carry mineral salts. On the lower slopes of the Evenlode valley, downstream as far as the neighbourhood of Charlbury, numerous springs issue from the junction of the Clypeus Grit and Upper Lias clay. Burford, in the Windrush valley, is supplied from a spring from this horizon.

In the mid-northern part of the district a number of boreholes derive water from the Sandy Beds of the Middle Lias, but it is doubtful if the quantity from the individual boreholes would be adequate for more than the supply of a house or two. At Fawler a good spring issues from the Marlstone.

The clay between the Chipping Norton Limestone and the Taynton Stone throws out numerous small springs in the neighbourhood of Swinbrook, and the Hampen Marly Beds, some good springs from the base of the White Limestone, such as Ford's Well, Fordwells, near Leafield, and that at Burford Signet. The thin, irregularly developed clay beds in the White Limestone subdivision account for some springs.

The Cornbrash is locally productive of small springs and supplies wells, sunk preferably through the rock into the underlying clay so as to provide storage.

On the dip slope, where the inclination of the rocks is greater than that of the surface, the water-bearing limestones pass down beneath the overlying clays; in such conditions overflow springs occur locally, as for instance at Broadwell and Brize Norton. In the higher north-western and mid-northern parts of the district boreholes have demonstrated that little water occurs deep down in the Great and Inferior Oolites: where water is encountered in the Oolites beneath the Oxford Clay in the lower ground as at Bampton and Oxford, it is usually too saline for potable purposes.

The Oxford Clay is almost waterless, but a few feeble springs issue from yellow loamy sand, which is probably on the horizon of the Kellaways Rock, near the base. The little water that may be collected in wells is liable to be saline: a small spring about a mile to the west of Cumnor bears the significant name of 'Physic Well.'

The Corallian rocks contain water but the direction of flow of much of it in the tract on which are situated the villages of Cumnor (part), Eaton, Appleton and Bessels Leigh, is southward; in that direction lie the Wootton Waterworks of the Abingdon Corporation. Owing to the adverse dip springs are few and feeble along the escarpment. The majority of the villages on the Corallian now have a piped service from the Oxford City's undertaking.

The Lower Greensand of the Boars Hill district contains water, and numerous small springs are thrown out from its base by the underlying Kimmeridge Clay. Supplies from wells sunk into it, however, proved totally inadequate in the droughts of 1921, '29, '33 and '34, moreover, both springs and wells in this neighbourhood are liable to pollution.

Superficial deposits, consisting of gravel and sand, are widely distributed on the surface of the Oxford Clay and have determined the sites of numerous villages. As the villages have been become enlarged and requirements in the matters of quantity and quality of water have progressed, such supplies have in many cases proved unsatisfactory; regional supplies from sources that do not fail and the water from which can be efficiently sterilized have taken their place.

Since the publication of the Geological Survey Memoirs on the water-supply of Oxfordshire and of Berkshire a number of wells have been sunk in the present district. Records of some of these have been given in appropriate places in this Memoir. In addition, the following may be quoted as indicating approximately the thicknesses of the formations between the Upper Lias and the Cornbrash.

BORING SOUTH OF NOTOAKS WOOD, COMBE

Situated 75 yds. south of the road, three quarters of a mile north-west by west of Combe Church, made, 1934. Height above O. D. about 385 ft.

Water was struck at 97 ft. and rose to 84 ft. On boring to 114 ft. 3 in. the water fell to 103 ft. 8 in. Another water-bearing bed was struck at 177 ft. 8 in. when the rest-level stood at 105 ft.

The well was sunk by Mr. F. B. Kingdon of Alcester. The supply is 200 gallons per hour, but no test for larger yield has been applied. The boring was by percussion and the classification shown on the opposite page is based only on the record of strata as given.

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			Thickness		Depth	
			Ft.	Ins.	Ft.	Ins.
		Well				
Cornbrash		Limestone rubble	1	0	1	0
Forest Marble	Wychwood Beds and ? Kemble Beds 20 ft.	Clay, brown	4	0	5	0
		Clay, blue	4	0	9	0
		Limestone	1	0	10	0
		Clay, brown	6	0	10	0
		Clay, blue	4	0	20	0
		Borehole				
		Limestone	1	0	21	0
Great Oolite	White Limestone 54 ft.	Clay	0	4	21	4
		Limestone	37	2	58	6
		Clay, blue	0	1	58	7
		Limestone	16	5	75	0
	Hampen Marly Beds 22 ft.	Marl, blue	0	2	75	2
		Limestone	8	10	84	0
		Clay, blue	2	6	86	6
		Limestone	3	6	90	0
		Clay, buff, and sand	2	0	92	0
		Clay, blue	0	10	92	10
		Limestone	2	8	95	6
		Clay, blue	1	6	97	0
	Taynton Stone 20 ft. 8 in.	Limestone	17	0	114	0
		Sand, buff siliceous	0	3	114	3
		Limestone	3	5	117	8
	Stonesfield Slate Beds	Sandstone	5	2	122	10
	Chipping Norton Limestone 21 ft. 7 in.	Limestone	9	0	131	10
		Clay, calcareous	2	4	134	2
		Limestone	10	3	144	5
	Roundhill Clay	Clay, black	0	4	144	9
Inferior Oolite		Rubbly Inferior Oolite	35	3	180	0
Upper Lias		Clay	10	0	190	0

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APPENDIX

LIST OF GEOLOGICAL SURVEY PHOTOGRAPHS IN SHEET 236.

Copies of these photographs are deposited for public reference in the Library of the Geological Survey, South Kensington, London. Prints and lantern slides are supplied at a fixed tariff on application to the Director.

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Number.
3175-7.—Greenhill Quarry, Bletchingdon. False-bedded Forest Marble limestone.
3178.—Smith's Quarry, Islip. Cornbrash on Forest Marble.
3179.—Quarry east of Hanborough Station. Cornbrash, Forest Marble clays and limestones, and top part of the Great Oolite.
3180.—Ditto. False-bedding in the Forest Marble limestones.
3181-3.—Hanborough Terrace Gravel seen in a pit north of the Swan Inn, Long Hanborough.
3184.—Hanborough Quarry. Cornbrash.
3185-7.—Ditto, showing the Clydoniceras Bed.
3188-9.—Blenheim Estate Pit, Long Hanborough. Pipes in gravel.
3190.—Wolvercot Brickyard, Wolvercot gravels on Oxford Clay.
3191-2.—Chawley Brickyard. Lower Greensand on Kimmeridge Clay.
6563.—Abandoned meander valley of the River Windrush, showing meander core. Asthall.
6564.—Dry valley at Fordwells, near Leafield.
6565.—Dry valley at Dean Bottom, Fulbrook.
6566.—Dry valley at Whiteoak Green.
6567.—Dry valley at Crawley.
6568. Stonesfield village and waste heaps of the Stonesfield slate-workings.
6569.—Unbedded (Plateau) Drift, near Waterman's Lodge, Cornbury Park Estate.
6570.—Great Oolite. Milton Quarries, Milton under Wychwood.
6572.—Kemble Beds, showing false-bedding. Hanborough Station Quarry.
6573-4.—Summertown-Radley Terrace river gravel, near Foxley Farm, Eynsham.
6575.—Solution pipe in gravel of the Summertown-Radley Terrace, Begbroke Hill, near Woodstock.
6576.—Hanborough Terrace river gravel. Fisher's Gate Quarry, North Leigh.
6578.—False-bedded Lower Greensand. Boars Hill, near Oxford.
6579.—Great Oolite. Lagshill Wood Quarry, Long Hanborough.
6580. 6582. } Great Oolite. Whitehill Wood Quarry, East End, North Leigh.
6581.—Summertown-Radley Terrace river gravel. Begbroke Hill, near Woodstock.
6583-4.—White Limestone, Kemble Beds and Wychwood Beds. Crawley Road Quarry, Witney.
6585.—Sand pit in glacial sand. Ascot under Wychwood.

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